# Radiological Health Data and Reports

VOLUME 9, NUMBER 4
APRIL 1968
(Pages 193–242)


U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

## INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

| Multiples and submultiples | Prefixes | Symbols | Pronunciations |
|---|---|---|---|
| $10^{12}$ | tera | T | tĕr' a |
| $10^{9}$ | giga | G | jĭ' ga |
| $10^{6}$ | mega | M | mĕg' a |
| $10^{3}$ | kilo | k | kĭl' o |
| $10^{2}$ | hecto | h | hĕk' to |
| 10 | deka | da | dĕk' a |
| $10^{-1}$ | deci | d | dĕs' i |
| $10^{-2}$ | centi | c | sĕn' ti |
| $10^{-3}$ | milli | m | mĭl' i |
| $10^{-6}$ | micro | μ | mi' kro |
| $10^{-9}$ | nano | n | năn' o |
| $10^{-12}$ | pico | p | pē' co |
| $10^{-15}$ | femto | f | fĕm' to |

## SYMBOLS, UNITS, AND EQUIVALENTS

| Symbol | Unit | Equivalent |
|---|---|---|
| BeV | billion electron volts | GeV |
| Ci | curie | $3.7\times10^{10}$ dps |
| cm | centimeter(s) | 0.394 inch |
| cpm | counts per minute | |
| dpm | disintegrations per minute | |
| dps | disintegrations per second | |
| eV | electron volt | $1.6\times10^{-12}$ ergs |
| g | gram(s) | |
| GeV | giga electron volts | $1.6\times10^{-3}$ ergs |
| kg | kilogram(s) | 1,000 g=2.205 lb |
| $km^2$ | square kilometer(s) | |
| kVp | kilovolt peak | |
| $m^3$ | cubic meter(s) | |
| mA | milliampere(s) | |
| $mCi/mi^2$ | millicuries per square mile | 0.386 $nCi/m^2$ ($mCi/km^2$) |
| MeV | million (mega) electron volts | $1.6\times10^{-6}$ ergs |
| mg | milligram(s) | |
| $mi^2$ | square mile(s) | |
| ml | milliliter(s) | |
| mm | millimeter(s) | |
| $nCi/m^2$ | nanocuries per square meter | 2.59 $mCi/mi^2$ |
| pCi | picocurie(s) | $10^{-12}$ curie = 2.22 dpm |
| R | roentgen | |
| rad | unit of absorbed radiation dose | 100 ergs/g |

# RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 9, Number 4, April 1968

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

*Radiological Health Data and Reports*, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

CONTENTS

CONTENTS—continued




**RADIOLOGICAL HEALTH DATA AND REPORTS**

Published under the direction of

James G. Terrill, Jr., Director and
Dr. Raymond T. Moore, Deputy Director
National Center for Radiological Health

by the Standards and Intelligence Branch
Donald L. Snow, Chief





Address correspondence to the Managing Editor, *Radiological Health Data and Reports*, National Center for Radiological Health, Public Health Service, Rockville, Md. 20852.





U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • National Center for Radiological Health

# Reports

## Summary of Iron-55 Contamination in the Environment and Levels in Humans

*Warren A. Brill* [1]

Levels of iron–55 in the environment and in food sources have been summarized. The average body burdens and resulting doses to the erythrocytes (red blood cells) of selected Alaskan Eskimos, and residents of the States of Washington, New York, and New Jersey are compared. Considering the erythrocytes as the critical organ, the dose rate from 1 pCi iron–55/mg stable iron is 0.095 mrad/yr. A body burden of 8 nCi, the average for Richland, Wash. residents, yields a yearly dose of 0.19 mrad, while 1,100 nCi, the average body burden for Eskimos on fish diets, yields a yearly dose of 26 mrad.

The objective of this paper is to summarize the data on levels of iron–55 in the environment and to review the dosimetric considerations of internally deposited iron–55. This radionuclide enters the environment primarily as a result of activation of iron–54 in thermonuclear devices tested in the atmosphere. It decays by electron capture (with a physical half-life of 2.4 years) to manganese–55. The only easily detectable radiation is a 5.9 keV X ray emitted with 28 percent of the disintegrations. Although both scintillation and proportional counting techniques have been used for quantitative determination, the sensitivity of either method depends upon the detector size and sample geometry (*1,2*). After suitable sample preparation, the detection limit of an electrodeposited sample is 6 to 8 pCi at 99-percent confidence level with a 60–100 minute count (*3–5*).

[1] Mr. Brill is staff officer, Radiation Exposure Intelligence Section, Standards and Intelligence Branch, and technical editor, *RHD&R*, National Center for Radiological Health, Rockville, Md. 20852.

### *Environmental and human exposure levels*

Iron–55 has been routinely sampled in precipitation by the Atomic Energy Commission's Health and Safety Laboratory (HASL) at several locations (*6*). In all cases, the levels of iron–55 have been corrected for decay by HASL to October 15, 1961. Environmental levels of iron–55 peaked in 1963–64 and have been decreasing since. Figures 1 through 6 show the

**Table 1. Iron-55 in precipitation [a] (mCi/km²)**

| Year | Westwood, N. J. | Appleton, Wisc. | Chattanooga, Tenn. | Oklahoma City, Okla. | Palo Alto, Calif. | Seattle, Wash. |
|---|---|---|---|---|---|---|
| 1962 | [b] (7–12) 28.70 | | | | | |
| 1963 | (1–12) 248.81 | (8–12) 41.42 | (8–12) 18.25 | (7–12) 31.33 | (7–12) 3.27 | (7–12) 39.76 |
| 1964 | (1–12) 107.57 | (1–12) 115.83 | (1–12) 160.57 | (1–12) 82.51 | (1–12) 27.20 | (1–12) 75.77 |
| 1965 | (1–12) 47.74 | (1–12) 44.94 | (1–12) 47.58 | (1–12) 54.12 | (1–12) 26.75 | (1–12) 39.50 |
| 1966 | (1–12) 17.93 | | | | | (1–12) 23.33 |
| 1967 | (1–2) 1.91 | | | | | (1) 1.22 |

[a] Decay corrected to 10/15/61. See reference *6*.
[b] Parentheses indicate chronological months of sampling.

pattern of fallout and precipitation for the HASL stations. Iron–55 levels in monthly precipitation approximately follow the precipitation pattern. The amount of iron–55 (decay corrected back to October 15, 1961) appears to have reached or be reaching a plateau (figure 7) for most of the stations. This means that the rate of atmospheric clearance of iron–55 is reaching its limiting value and that environmental levels will then show a net decrease with time. When the deposition is corrected for radioactive decay (figure 8), it is seen that the total accumulated deposition is actually decreasing at the present time. The data are most complete for the Westwood, N.J. station and a semilog plot of the yearly deposition shows an expotential decrease with a half-time of 10 months (figure 9). This exponential decrease is open to many interpretations but may be due solely to meteorological considerations (cf. 7).

In 1965 the first study of iron–55 in human, animal and plant populations was published by Palmer and Beasley (*4*). The content of iron–55 in various foods was related to the body burdens of certain animals and humans in the States of Washington and Alaska. These levels of iron–55 in foods and in humans are given in tables 2 and 3, respectively. As can be seen, Anaktuvuk Eskimos had an average body burden of 61 nCi in January 1965, 7.6 times the average burden reported for Richland, Wash. residents. Using data of Wrenn and Cohen, the average iron–55 body burdens of selected New York and New Jersey adult males and females for 1965–1966 is calculated to be 13.3 nCi (10.6 for males and 16.5 for females), also much lower than Alaskan Eskimos (*8*).

The Alaskan iron–55 food chain described by Palmer and Beasley was that of lichen-caribou-man, which is the same route as for cesium–137 (*4*). Iron–55 reaches vegetation primarily via air and precipitation deposition (*4*). Iron is also taken up by the roots, but a very small percentage reaches the vegetation via root uptake because of isotopic dilution of the radioiron by the stable iron in the soil (*9*). For example, whole wheat flour from various sources has been found to contain ten times as much iron–55 as bleached white flour, suggesting that the iron–55 is probably deposited on the outer shell of the wheat (*4*).

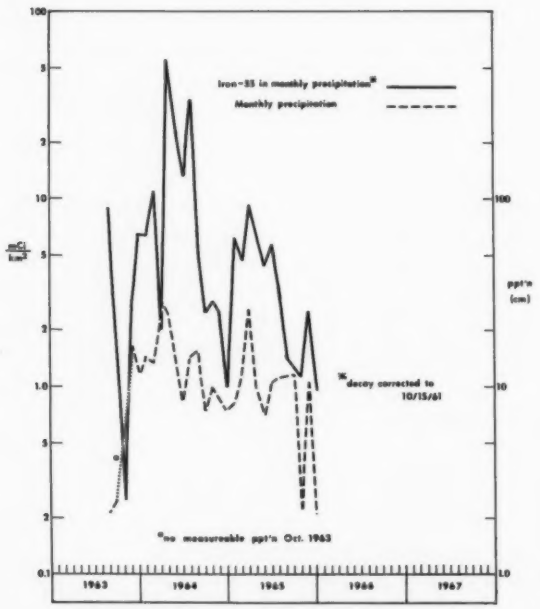


Figure 1. Iron–55 in monthly precipitation, Chattanooga, Tenn.

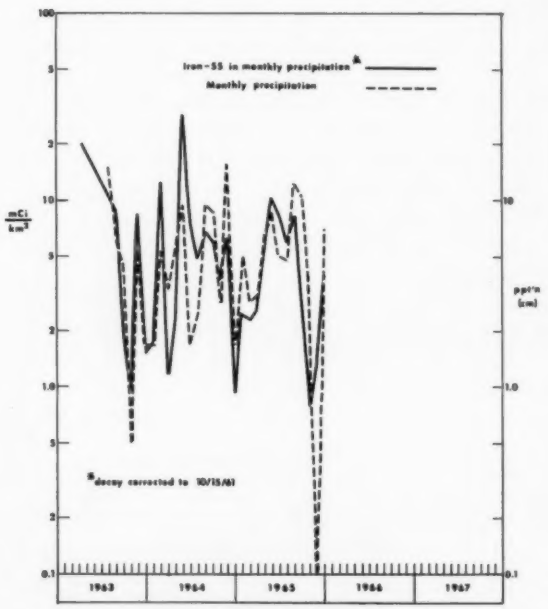


Figure 2. Iron–55 in monthly precipitation, Oklahoma City, Okla.

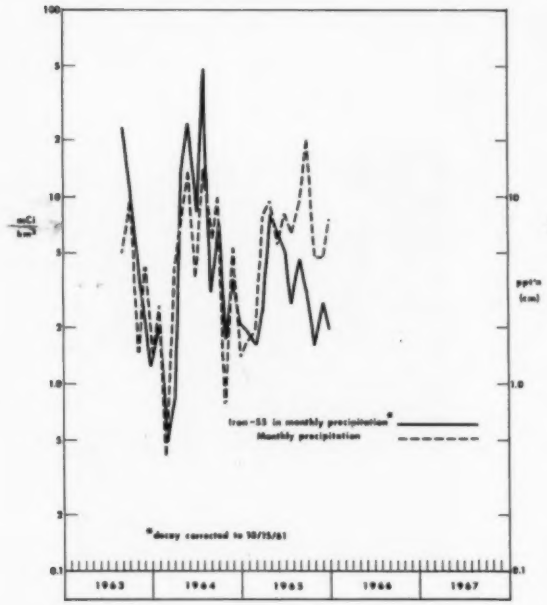


Figure 3. Iron–55 in monthly precipitation, Appleton, Wis.

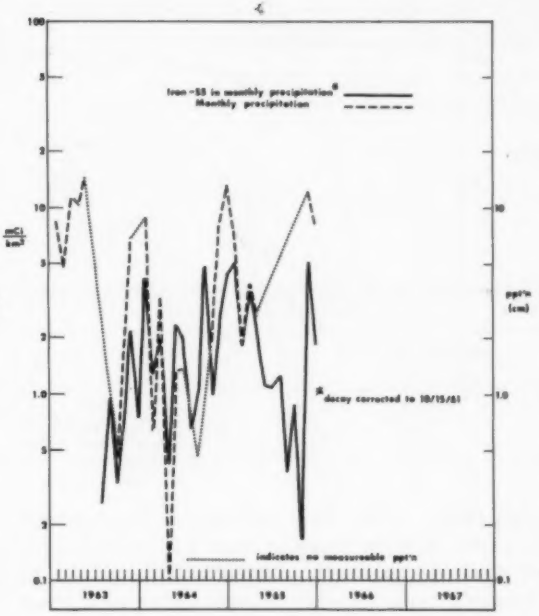


Figure 4. Iron–55 in monthly precipitation, Palo Alto, Calif.

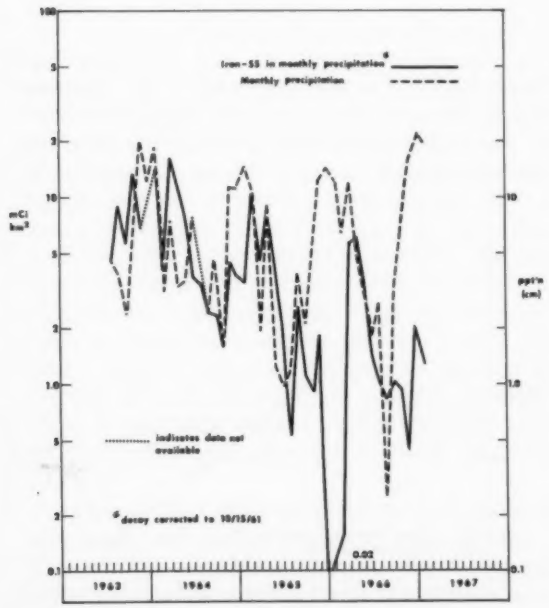


Figure 5. Iron–55 in monthly precipitation, Seattle, Wash.

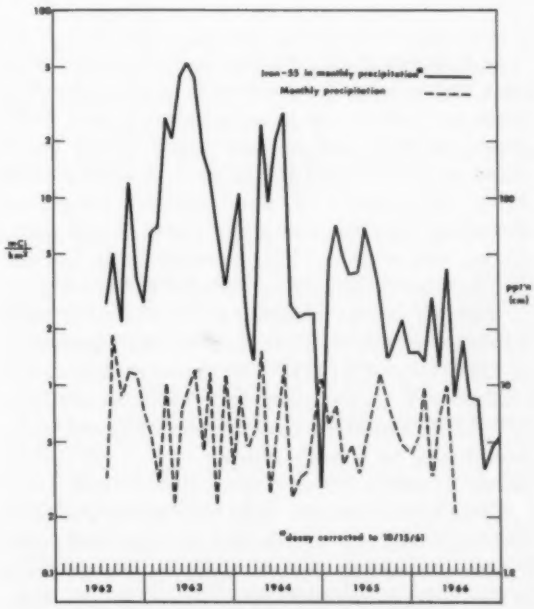


Figure 6. Iron–55 in monthly precipitation, Westwood, N.J.

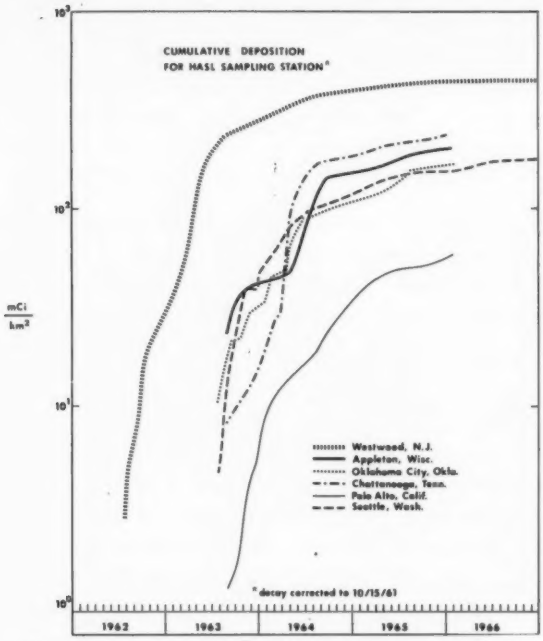


**Figure 7. Iron–55 in monthly precipitation, cumulative deposition for HASL sampling stations from date of first reported sample**

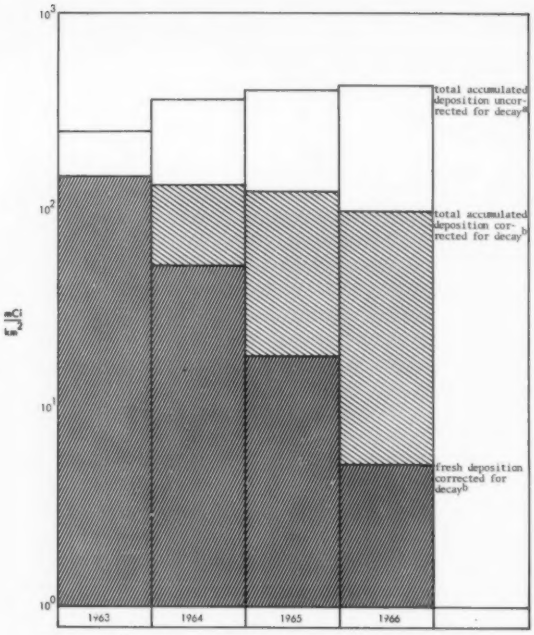


**Figure 8. Total cumulative deposition of iron–55 in monthly precipitation at Westwood, N.J.**
**[a]Data from reference 6 uncorrected for decay normalized to October 15, 1961 (cf. figures 6 and 7)**
**[b]Data from reference 6 corrected for decay to October 15 of sampling year**

In another study, Palmer and Beasley found that the marine food chain is able to concentrate iron–55 to an even greater extent, with levels in tuna and salmon being 20–30 times those of caribou and 100 times U.S. beef muscle (*10*). The livers of some salmon caught at Kotzebue, Alaska, contained about 2 $\mu$Ci iron–55/kg wet weight. The average body burden of Eskimos primarily on fish diets were higher (1,100 nCi, with a range of 212–2,300 nCi) than Eskimos whose diet contained lesser amounts of fish (table 4) (*11*). The opposite is true for cesium–137, *i.e.*, the average intake of cesium–137 for Eskimos on caribou and reindeer diets would lead to a body burden of 3–5 nCi, compared to about 0.3 nCi for a diet of fish (*12*).

The higher iron–55 body burdens of Alaskan Eskimos may be attributed to the radioiron-contaminated fish in their diets; however, there is also a large percentage of iron-deficient individuals among the Eskimos (*9*). Furthermore, females have a higher turnover rate of iron due to menstrual blood loss and normally have higher body burdens than males; this has been advanced as a reason for sex distinction (*9*).

Several explanations exist for the high concentrations of iron–55 found in marine or-

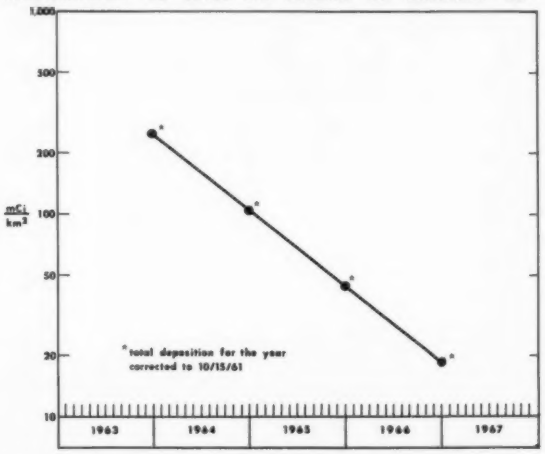


**Figure 9. Iron–55 in yearly precipitation, Westwood, N.J.**

Table 2. Content of iron-55 in various foods purchased in December 1964 (*4*)

| Food | Content | |
|---|---|---|
| | Stable iron (mg/kg) | Iron-55 (nCi/kg) |
| Alaskan caribou: | | |
| Round steak | 53 | 3.6 |
| Round steak | 43 | 2.9 |
| Liver | 208.8 | 28.7 |
| Washington State meats: | | |
| Beef, round steak | 22 | 0.86 |
| Beef, round steak | 25 | .92 |
| Beef, round steak | 22 | .30 |
| Beef liver | 95 | .95 |
| Beef liver | 45 | 1.2 |
| Elk, lean | 30 | 1.7 |
| Elk, lean | 37 | 1.8 |
| Bologna | 9.1 | .34 |
| Pork and ham loaf | 16 | .06 |
| Pork chops | 6.7 | .013 |
| Hamburger | 27 | .25 |
| Weiners | 12 | .21 |
| Pacific seafoods: | | |
| Smelt | 8.1 | 7.47 |
| Salmon | 5.0 | 3.42 |
| Tuna | 6.9 | 6.42 |
| Tuna | 2.3 | 5.19 |
| Cod | 3.1 | 0.24 |
| Clams | 17.7 | .045 |
| Oysters | 170 | .087 |
| Oysters (Atlantic) | 98 | .057 |
| General: | | |
| Whole-wheat flour | 29 | 0.31 |
| Whole-wheat flour | 46 | .27 |
| Bleached white flour | 30 | .063 |
| Bleached white flour | 31 | .036 |
| Bleached white flour | 33 | .049 |
| Bleached white flour | 31 | .026 |
| Wheat flakes | 56 | .25 |
| 40% bran flakes | 48 | .37 |
| Quaker oats | 41 | .15 |
| Eggs | 25 | .54 |
| Eggs | 20 | .055 |
| Eggs | 23 | .16 |
| Lettuce | 4.5 | .011 |
| Carrots | 4.1 | .028 |

ganisms. Sea water contains only 10 $\mu$g stable iron/liter, therefore, the radionuclide is not isotopically diluted to the same extent as on land (*4*). In addition, most of the marine species of concern are fast growing fish, have a lower content of iron than land animals and probably take up and retain most of the iron–55 that is ingested and absorbed (*10*). An explanation offered is that the iron–55 is in a chemical form more readily available to fast growing fish (*e.g.*, salmon) than stable iron. The specific activity of iron–55 in salmon is about $10^3$ to $10^4$ times higher than that of particulates less than 0.3 microns in diameter filtered from sea water (*13*).

Although the rate of deposition of iron–55 has been decreasing (table 1 and figures 7 through 9), amounts in humans have been increasing because of the time lag due to non-equilibrium conditions. With the continued cessation of high yield atmospheric tests of

Table 3. Iron-55 in humans (*4*)

| Subject | Date sampled | Number of subjects | Estimated total blood volume (liter) | Blood concentration (nCi/liter) | Total body burden (nCi) | |
|---|---|---|---|---|---|---|
| | | | | | Average | Range |
| Anaktuvuk Eskimos | 1/65 | 7 | 5 | 7.3 | 61 | 32–89 |
| Richland, Wash. residents | 11/64 | 4 | 5 | 0.96 | 8 | 4–16 |

Table 4. Iron-55 body burdens associated with diets of Alaskan male Eskimos (*11*)

| Diet | Average body burdens (nCi) |
|---|---|
| Fish | 344 |
| Fish and caribou | 250 |
| Caribou | 80 |

thermonuclear devices and after radioactive equilibrium has been reached between the rate of buildup and the rate of decay in environmental and food sources, the amounts of iron–55 in man will decrease. The precise calculation of this time period is difficult, however, because the following parameters are unkown:

a. rate of fallout of iron–55 at the location in question;
b. effective half-life of iron–55 deposited on the lichen (for people on caribou diets);
c. effective half-life in the land and/or marine food sources; and
d. effective half-life of iron–55 in man as derived from these sources.

*Dosimetry*

The International Commission on Radiological Protection (ICRP) recommends the spleen as the critical organ for iron–55 and sets the maximum permissible body burden (q) for the public at 100 $\mu$Ci, which will result in a dose rate of 1.5 rad/yr to the critical organ (*14,15*).

Wrenn (*1*) and Wrenn and Cohen (*8*) have derived equations for calculation of dose to whole blood and erythrocytes (red blood cells). These are based upon the fact that iron accounts for 0.0057 percent of the body weight (*14*), with 60–75 percent of total body iron in the hemoglobin (*16*). In addition, the loss of

iron from the hemoglobin is less than 0.1 percent per day (*16*). Upon transmutation and de-excitation, iron–55 and its daughter, manganese–55, principally emit a 5.9 keV X ray or a 5 keV auger electron. The latter has a range in water of 1 micron and will be absorbed within the 8 micron long by 2 micron thick erythrocyte. Because there are very short range radiations, it is more realistic to consider the erythrocytes rather than the whole blood when calculating doses from iron–55 (*1,8*). Wrenn analyzed samples from a blood bank, and since data were not available concerning sex and size, the total iron stores of each individual was estimated to be 4 grams. Utilizing the suggestion of Peacock, *et al.* (*17*), that all the energy of the X ray is deposited in the whole blood, Wrenn and Cohen calculated the dose due to the K-shell X rays from 1 pCi iron–55/mg stable iron as 0.282 μrad/week. This is probably an overestimate of whole blood dose because some of the energy of the X ray will be deposited in surrounding tissues. This calculation underestimates the dose to the erythrocytes because it does not take energy deposition by auger electrons into account. Since the mass of the erythrocytes constitute 47 percent of the mass of the total blood (*18*) and the ionization potential of the K-shell of manganese is 6.54 keV, the dose rate to the erythrocytes from 1 pCi iron–55/mg stable iron is composed of the dose rate due to X rays plus the dose rate due to auger electrons, as follows:

$$D = D_X + D_K + D_L$$

where, $D$ = total dose rate,
$D_X$ = dose rate due to K-shell X rays,
$D_K$ = auger electron dose rate from K-shell capture, and
$D_L$ = auger electron dose rate from L-shell capture.

The dose rate is then 1.83 μrads/week for 1pCi iron–55/mg stable iron. A continuous burden of 1 pCi iron–55/mg stable iron will result in a yearly dose of 0.095 mrad.

Palmer and Beasley used Wrenn's earlier method of dose calculation and determined that a constant total body burden of 1,000 nCi will produce an erythrocyte dose rate of "about 30 mrad/yr" (*1, 9*). A more precise estimate of the dose rate can be calculated if the fluorescence yield [2] of manganese–55 is taken into account (*9*); this would then be about 24 mrad/yr.

Recent investigators treat the erythrocytes as the critical organ, and it appears that the ICRP recommendation of the spleen as the critical organ for iron–55 should be re-evaluated. The calculated body burden of iron–55 considering the erythrocytes as the critical organ would then be:

$$\text{iron–55 body burden} = (A/B)\ (C)\ (D)$$

where, $A$ = 1 pCi iron–55/mg stable iron in the body,
$B$ = the dose rate that results from A (0.095 mrad/yr),
$C$ = dose rate limits for members of the public for iron–55 ($1.5 \times 10^3$ mrad/yr), and
$D$ = average total body content of stable iron ($4 \times 10^3$ mg).

Substituting the above numerical values, the calculated body burden for iron–55 is 63.2 μCi for the public. Wrenn and Cohen have suggested the bone marrow as the next tissue of concern, but more data is needed on uptake of iron–55 by marrow in humans and dosimetric evaluations (*8*).

Wrenn (*19*) has also proposed that the ferritin aggregates, which are present in liver, spleen, and reticulocytes and contain 20 percent iron by weight, may receive high locally delivered doses. It is estimated that the dose to ferritin aggregates is approximately 400 times that to the erythrocytes, although the total mass involved is considerably less than that of the erythrocytes.

*Summary*

Iron–55 is found in low levels in fallout deposition and food sources. For example, the total accumulated deposition at Seattle, Wash., from July 1963 to October 1966 was 176.01 mCi/km²; iron–55 levels in Washington State meats varied from 0.013 nCi/kg for pork chops to 1.8 nCi/kg for lean elk meat. No data is

[2] The probability that an atom whose electronic structure has been excited will emit an X-ray photon in the first transition, rather than an auger electron.

available for iron–55 deposition in the State of Alaska, however, Alaskan caribou steak contained about 3 nCi/kg, caribou liver contained 28.7 nCi/kg and salmon liver almost 2 $\mu$Ci/kg wet weight.

Ingestion of these and other contaminated foodstuffs resulted in the following body burdens and doses to the erythrocytes:

| Population group | Average body burden (nCi) | Yearly dose to erythrocytes (mrad) |
|---|---|---|
| Richland Wash. residents–January 1965 (*4*) | 8 | 0.19 |
| Selected N. Y. and N. J. residents–1965–66 (*8*) | 13.3 | 0.32 |
| Anaktuvuk Eskimos–January 1965 (*4*) | 61 | 1.4 |
| Eskimos on fish diet (*10*) | 1,100 | 26 |

REFERENCES


(*1*) WRENN, M. E. $^{55}$Fe in humans. Radioactivity Studies, M. Eisenbud and H. G. Petrow, Editors, NYO–3086–1 (September 1, 1965) pp. 10–1ff.

(*2*) COSOLITO, F. J., N. COHEN, and H. G. PETROW. Simultaneous determination of iron–55 and stable iron by liquid scintillation counting. Anal Chem (in press) (Preprint supplied by permission of Mr. Cosolito.)

(*3*) PERSSON, B. $^{55}$Fe from fallout in lichen, reindeer and Lapps. Radiological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966, B. Aberg and F. P. Hungate, Editors. Pergamon Press, London (1967) pp. 253–258.

(*4*) PALMER, H. E. and T. M. BEASLEY. Iron–55 in humans and their foods. Science 149:431–432 (1965).

(*5*) JAAKOLA, T. $^{55}$Fe and stable iron in some environmental samples in Finland. Radiological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. B. Aberg and F. P. Hungate, Editors. Pergamon Press, London (1967) pp. 247–251.

(*6*) U.S. ATOMIC ENERGY COMMISSION, HEALTH AND SAFETY LABORATORY. Fallout Program Quarterly Summary Report Appendix: HASL–184, B–6 (January 1, 1968).

(*7*) UNITED NATIONS SCIENTIFIC COMMITTEE ON THE EFFECTS OF ATOMIC RADIATION. United Nations Scientific Committee on the Effects of Atomic Radiation, Supplement No. 16 (A/5216), paragraph 45 (1962) p. 241.

(*8*) WRENN, M. E. and N. COHEN. Iron–55 from nuclear fallout in the blood of adults: dosimetric implications and development of a model to predict levels in blood. Health Physics 13:1075 (November 1967).

(*9*) PALMER, H. E. and T. M. BEASLEY. Iron–55 in man and the biosphere. Health Physics 13:899 (August 1967).

(*10*) PALMER, H. E. and T. M. BEASLEY, $^{55}$Fe in the marine environment and in people who consume ocean fish. Radiological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966, B. Aberg and F. P. Hungate, Editors. Pergamon Press, London (1967) pp. 259–262.

(*11*) PALMER, H. E., T. M. BEASLEY, and J. M. AASE. $Fe^{55}$ in Alaskan natives. Report of work performed under Contract No. AT (45–1)–1830 between U.S. Atomic Energy Commission and Battelle Memorial Institute.

(*12*) HANSON, W. C., H. E. PALMER, and B. I. GRIFFIN. Radioactivity in northern Alaskan Eskimos and their foods, summer 1962. Health Physics 10:421 (June 1964).

(*13*) PALMER, H. E., J. C. LANGFORD, T. M. BEASLEY, C. E. JENKINS and J. M. AASE. Levels of iron–55 in humans, animals, and food, 1964–1967. Radiol Health Data Rep (in press).

(*14*) INTERNATIONAL COMMITTEE ON RADIOLOGICAL PROTECTION. Recommendations of the International Commission on Radiological Protection, Report of Committee II on Permissible Dose for Internal Radiation. Pergamon Press, New York (1959).

(*15*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendations of the International Commission of Radiological Protection, ICRP Publication 9: Pergamon Press, New York (1967).

(*16*) PRICE, P. C. Iron turnover in man. Dynamic Clinical Studies Radioisotopes, R. M. Kniseley, W. N. Tauxe, and E. B. Anderson, Editors. U.S. Atomic Energy Commission: TID–7678 (1964) pp. 537–564.

(*17*) PEACOCK, W. C., R. D. EVANS, J. D. IRVINE, Jr., W. M. GOOD, A. F. KIP, S. WEISS, and J. G. GIBSON. The use of two radioactive isotopes of iron in tracer studies of erythrocytes. J Clin Invest 25: 605 (1946).

(*18*) ALTMAN, P. L. Blood and other body fluids. Federations of American Societies for Experimental Biology, Washington, D.C. (1961).

(*19*) WRENN, M. E. The dosimetry of $^{55}$Fe. Presented at the first meeting of the International Radiation Protection Association, Rome (August 1966) in press.

# SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Federal and State agencies are involved in efforts to monitor continuously the dietary intake of radionuclides. The most direct measure of radionuclide intake would be obtained through radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternate method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Fresh milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, fresh milk is the single food item often used in estimating the intake of selected radionuclides by the general population and/or specific population groups. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of fresh milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5, 6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

REFERENCES

(*1*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).
(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).
(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action for strontium–89, strontium–90, and cesium–137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).
(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).
(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press, New York, N.Y. (1959).
(*6*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 6. Pargamon Press, New York, N.Y. (1965).

## National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

| Program | Period reported | Last presented |
|---|---|---|
| Radiostrontium in milk, HASL | July–December 1966 | September 1967 |

### 1. Pasteurized Milk Network December 1967

*National Center for Radiological Health* and *National Center for Urban and Industrial Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) is designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, Washington, D.C., the Canal Zone, and Puerto Rico. The

**Table 1. Analytical errors associated with determinations of radionuclide concentrations in a milk sample**

| Nuclide | Concentration (pCi/liter) | Error [a] (pCi/liter) | Concentration (pCi/liter) | Error [a] (percent of concentration) |
|---|---|---|---|---|
| Strontium-89 | < 50 | 5 | ≥ 50 | 10 |
| Strontium-90 | < 20 | 2 | ≥ 20 | 10 |
| Iodine-131 | <100 | 10 | ≥100 | 10 |
| Cesium-137 | <100 | 10 | ≥100 | 10 |
| Barium-140 | <100 | 10 | ≥100 | 10 |

[a] Two standard deviations.

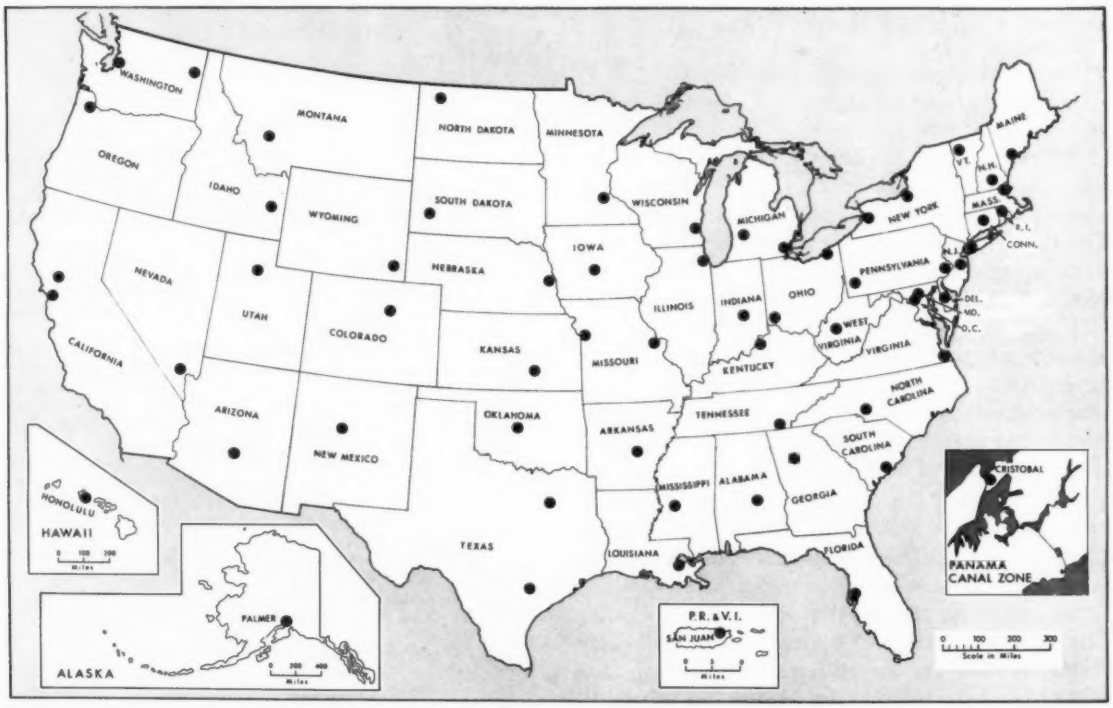


**Figure 1. Pasteurized Milk Network sampling stations**

**Table 2. Average concentrations of radionuclides in milk for December 1967 and the 12-month period, January through December 1967[a]**

| Sampling location | | Radionuclide concentration (pCi/liter) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Strontium-89 | | Strontium-90 | | Iodine-131 | | Cesium-137 | | Barium-140 | |
| | | Jan 1967–Dec 1967 | Dec 1967 | Jan 1967–Dec 1967 | Dec 1967 | Jan 1967–Dec 1967 | Dec 1967 | Jan 1967–Dec 1967 | Dec 1967 | Jan 1967–Dec 1967 | Dec 1967 |
| Ala: | Montgomery | 0 | 0 | 10 | 10 | 2 | 0 | 15 | 7 | 0 | 0 |
| Alaska: | Palmer | 0 | 0 | 7 | 6 | 0 | 0 | 20 | 19 | 0 | 0 |
| Ariz: | Phoenix | 0 | 0 | 2 | 1 | 0 | 0 | 2 | 5 | 0 | 3 |
| Ark: | Little Rock | 0 | 0 | 23 | 20 | 1 | 0 | 20 | 18 | 0 | 0 |
| Calif: | Sacramento | 2 | 0 | 3 | 0 | 2 | 0 | 4 | 12 | 1 | 3 |
| | San Francisco | 2 | 0 | 3 | 1 | 1 | 0 | 2 | 7 | 0 | 0 |
| C. Z: | Cristobal | 0 | 0 | 4 | 2 | 0 | 0 | 20 | 7 | 0 | 0 |
| Colo: | Denver | 1 | 4 | 6 | 4 | 1 | 0 | 5 | 11 | 0 | 0 |
| Conn: | Hartford | NA | NA | 9 | 10 | 1 | 0 | 18 | 3 | 0 | 0 |
| Del: | Wilmington | NA | NA | 11 | 9 | 1 | 0 | 14 | 8 | 0 | 0 |
| D. C: | Washington | 0 | 0 | 10 | 9 | 0 | 0 | 10 | 3 | 0 | 0 |
| Fla: | Tampa | 0 | 0 | 8 | 7 | 1 | 0 | 75 | 64 | 0 | 0 |
| Ga: | Atlanta | 0 | 0 | 16 | 14 | 3 | 0 | 24 | 15 | 0 | 0 |
| Hawaii: | Honolulu | 0 | 0 | 4 | 4 | 2 | 0 | 9 | 7 | 2 | 0 |
| Idaho: | Idaho Falls | 1 | 2 | 6 | 5 | 0 | 0 | 8 | 6 | 0 | 2 |
| Ill: | Chicago | 0 | 0 | 9 | 9 | 0 | 0 | 14 | 13 | 0 | 0 |
| Ind: | Indianapolis | [b] 0 | NA | 9 | 8 | 0 | 0 | 10 | 7 | 0 | 0 |
| Iowa: | Des Moines | 1 | 0 | 8 | 6 | 0 | 0 | 7 | 11 | 1 | 3 |
| Kans: | Wichita | 1 | 0 | 8 | 9 | 0 | 0 | 4 | 3 | 0 | 0 |
| Ky: | Louisville | 1 | 0 | 13 | 10 | 0 | 0 | 8 | 0 | 1 | 0 |
| La: | New Orleans | 1 | 0 | 24 | 20 | 1 | 0 | 28 | 21 | 1 | 0 |
| Maine: | Portland | 0 | NA | 12 | 14 | 0 | 0 | 36 | 30 | 0 | 0 |
| Md: | Baltimore | 0 | 0 | 11 | 10 | 0 | 0 | 12 | 4 | 0 | 0 |
| Mass: | Boston | 0 | 0 | 12 | 11 | 0 | 0 | 31 | 20 | 0 | 0 |
| Mich: | Detroit | | | 9 | 8 | 1 | 0 | 15 | 9 | 0 | 0 |
| | Grand Rapids | [b] 0 | NA | 10 | 11 | 0 | 0 | 19 | 16 | 0 | 0 |
| Minn: | Minneapolis | 1 | 0 | 13 | 12 | 0 | 0 | 13 | 9 | 0 | 0 |
| Miss: | Jackson | 1 | 0 | 19 | 14 | 2 | 0 | 17 | 13 | 0 | 0 |
| Mo: | Kansas City | 2 | 2 | 9 | 7 | 1 | 0 | 3 | 3 | 1 | 0 |
| | St. Louis | 2 | 0 | 10 | 10 | 0 | 0 | 7 | 6 | 0 | 0 |
| Mont: | Helena | 1 | 0 | 6 | 6 | 0 | 0 | 9 | 11 | 0 | 0 |
| Nebr: | Omaha | 0 | 0 | 9 | 7 | 1 | 0 | 5 | 0 | 0 | 0 |
| Nev: | Las Vegas | 0 | 0 | 2 | 2 | 0 | 0 | 2 | 0 | 0 | 0 |
| N. H: | Manchester | [b] 0 | NA | 14 | 13 | 0 | 0 | 43 | 33 | 0 | 0 |
| N. J: | Trenton | [b] 0 | NA | 10 | 8 | 0 | 0 | 15 | 5 | 0 | 0 |
| N. Mex: | Albuquerque | 0 | 0 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 3 |
| N. Y: | Buffalo | [b] 0 | NA | 9 | 9 | 0 | 0 | 15 | 9 | 0 | 0 |
| | New York | [b] 0 | NA | 11 | 9 | 0 | 0 | 16 | 7 | 0 | 0 |
| | Syracuse | [b] 0 | NA | [c] 10 | NA | [c] 1 | NA | [c] 17 | NA | [c] 0 | NA |
| N. C: | Charlotte | 0 | 0 | 17 | 13 | 1 | 1 | 16 | 10 | 1 | 0 |
| N. Dak: | Minot | 3 | 3 | 14 | 12 | 0 | 0 | 13 | 13 | 0 | 0 |
| Ohio: | Cincinnati | [b] 0 | NA | 10 | 8 | 0 | 0 | 10 | 1 | 0 | 0 |
| | Cleveland | [b] 0 | NA | 10 | 9 | 0 | 0 | 14 | 12 | 0 | 0 |
| Okla: | Oklahoma City | 0 | 0 | 10 | 9 | 1 | 0 | 6 | 4 | 0 | 0 |
| Ore: | Portland | 2 | 0 | 8 | 7 | 2 | 0 | 13 | 6 | 0 | 0 |
| Pa: | Philadelphia | [b] 0 | NA | 10 | 6 | 1 | 0 | 13 | 16 | 0 | 0 |
| | Pittsburgh | NA | NA | 13 | 11 | 1 | 0 | 20 | 14 | 0 | 0 |
| P. R: | San Juan | 1 | 0 | 5 | 5 | 0 | 0 | 14 | 5 | 0 | 0 |
| R. I: | Providence | [b] 0 | NA | 11 | 10 | 0 | 0 | 25 | 17 | 0 | 0 |
| S. C: | Charleston | 0 | 0 | 16 | 14 | 5 | 0 | 32 | 24 | 0 | 0 |
| S. Dak: | Rapid City | 2 | 0 | 12 | 10 | 1 | 0 | 12 | 7 | 1 | 2 |
| Tenn: | Chattanooga | 0 | 0 | 16 | 13 | 1 | 0 | 16 | 10 | 1 | 0 |
| | Memphis | 0 | 0 | 13 | 10 | 1 | 0 | 5 | 3 | 0 | 0 |
| Tex: | Austin | 0 | 0 | 4 | 4 | 3 | 0 | 4 | 7 | 0 | 0 |
| | Dallas | 0 | 0 | 9 | 7 | 2 | 0 | 7 | 0 | 0 | 0 |
| Utah: | Salt Lake City | 1 | 0 | 6 | 6 | 1 | 0 | 11 | 11 | 0 | 0 |
| Va: | Norfolk | 0 | 0 | 11 | 9 | 1 | 0 | 19 | 9 | 0 | 0 |
| Vt: | Burlington | [b] 0 | NA | 13 | 11 | 1 | 0 | 12 | 13 | 0 | 0 |
| Wash: | Seattle | 2 | 3 | 11 | 11 | 0 | 0 | 27 | 13 | 0 | 3 |
| | Spokane | 0 | 0 | 10 | 13 | 0 | 0 | 17 | 11 | 0 | 0 |
| W. Va: | Charleston | 0 | 0 | 12 | 10 | 0 | 0 | 8 | 6 | 0 | 0 |
| Wisc: | Milwaukee | NA | NA | 7 | 7 | 0 | 0 | 15 | 10 | 0 | 0 |
| Wyo: | Laramie | 0 | 0 | 5 | 5 | 0 | 0 | 5 | 7 | 0 | 0 |
| Network monthly average | | 0 | 0 | 10 | 9 | 1 | 0 | 15 | 11 | 0 | 0 |

[a] See text for averaging procedures.
[b] Based on only 1 month's data.
[c] Based on only 11 month's data.
NA, no analysis for the period reported.

most recent description of the sampling and analytical procedures employed by the PMN appeared in the January 1968 issue of *Radiological Health Data and Reports* (*1*). Reference should also be made to the February 1968 issue (*2*), in which several changes in the interpretation and reporting of data were introduced.

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. Table 2 contains averages for December 1967 and 12-month averages for the period January 1967 through December 1967. The 12-month averages facilitate evaluations of population exposure with respect to the guidance provided by the Federal Radiation Council, which suggests average total daily intakes averaged over periods of a year, as an appropriate criterion (*3*). The average radionuclide concentrations are based on results obtained from samples collected weekly. Whenever weekly concentrations were less than or equal to the appropriate minimum detectable levels, zero was used for averaging purposes (*2*). At very low radionuclide concentrations this often results in averages lower than the minimum detectable concentration of a single sample, but reflects that some of the samples making up the average were above detectable levels. The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium–89, 5; strontium–90, 2; iodine–131, cesium–137, and barium–140, 10. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

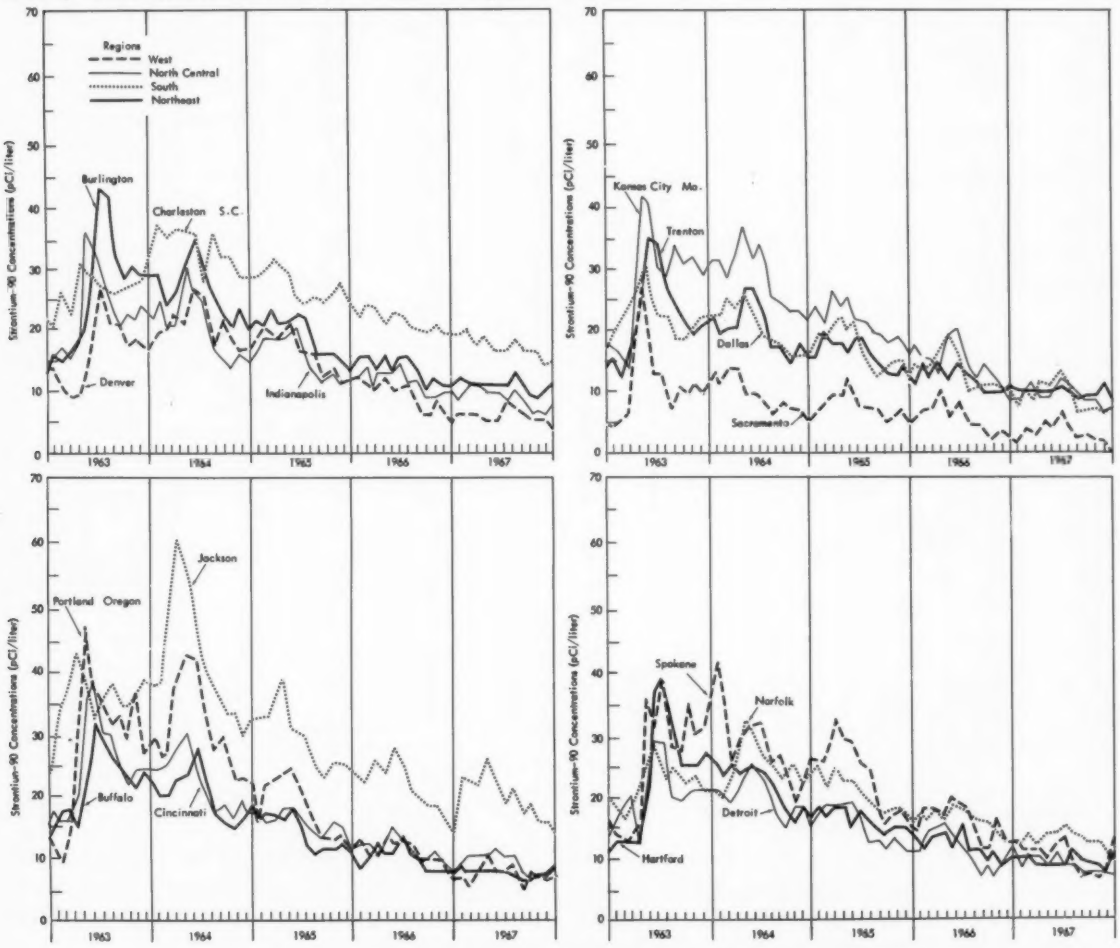


**Figure 2. Strontium–90 concentrations in pasteurized milk, 1961–December 1967**

## 2. Canadian Milk Network December 1967 [1]

*Radiation Protection Division*
*Department of National Health and Welfare*

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. In the beginning, analyses were carried out on samples of powdered milk obtained from processing plants. In January 1963, analysis of liquid whole milk was begun. This change allowed more representative samples of milk consumed to be obtained, and allowed the milk sampling locations (figure 3) to be chosen in the same areas as the air and precipitation stations. At present, the analyses include determinations of cesium–137 and strontium–90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine–131. The results of the spot checks for iodine–131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium–90, cesium–137 and stable potassium and calcium.

### *Analytical methods*

Since it represents a more sensitive method, radiochemistry, rather than gamma spectrometry, is used to determine iodine–131 (*4*). For the analysis of radiostrontium, carrier strontium is added to a 1-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infrared lamps. The residue is ashed in a muffle furnace at 450°C and dissolved in dilute nitric acid; strontium is separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low-background beta counter. Strontium–90 is determined separately by extracting and counting its yttrium–90 daughter, while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium–137 is determined by gamma scintillation spectrometry using a scintillation crystal

[1] Prepared from information and data in the January 1968 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

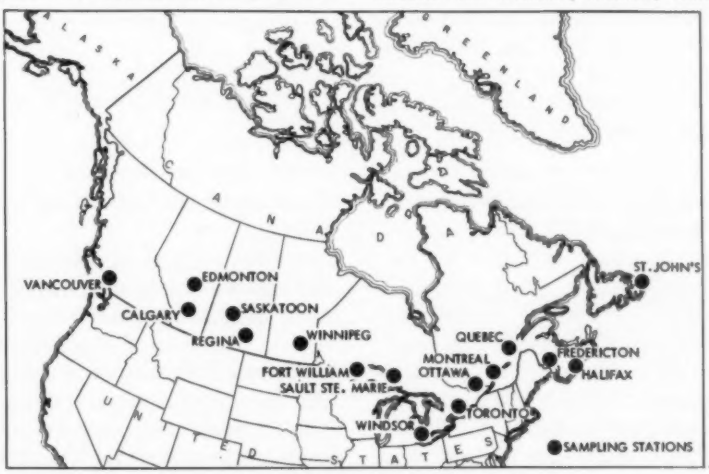


**Figure 3. Canadian milk sampling stations**

and multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5- by 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum is then recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium–40 concentration is determined and the Compton contribution of this radionuclide to the cesium–137 photopeak is subtracted to obtain the cesium–137 concentration. The stable potassium content is estimated from the potassium–40 concentration.

*Sources of error*

In the iodine–131 and strontium–89 determinations, tests indicate that the statistical error (95-percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radionuclide in the milk because it depends only on the recovery of the carrier. In the determination of cesium–137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 5.

**Table 5. Total error for various radionuclide concentrations in milk[a]**

| Nuclide | Error for 10 pCi/liter (percent) | Error for 50 pCi/liter (percent) | Error for 100 pCi/liter (percent) |
|---|---|---|---|
| Strontium-89 | ±25 | ±20 | ±15 |
| Strontium-90 | ±15 | ±10 | ±10 |
| Iodine-131 | ±50 | ±20 | ±10 |
| Cesium-137 | ±60 | ±20 | ±10 |

[a] All errors are $2\sigma$ values, representing 95-percent confidence level.

*Results*

Table 6 presents monthly averages of strontium–90, cesium–137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine–131 and strontium–89 indicate that all samples had insignificant levels of these radionuclides.

The results show that radionuclide concentrations in Canadian whole milk remained well below the permissible levels.

**Table 6. Stable elements and radionuclides in Canadian whole milk, December 1967**

| Station | Calcium (g/liter) | Potassium (g/liter) | Strontium-90 (pCi/liter) | Cesium-137 (pCi/liter) |
|---|---|---|---|---|
| Calgary | 1.14 | 1.4 | 12 | 17 |
| Edmonton | 1.15 | 1.6 | 8 | 32 |
| Ft. William | 1.09 | 1.5 | 18 | 27 |
| Fredericton | 1.09 | 1.6 | 15 | 24 |
| Halifax | 1.15 | 1.6 | 12 | 26 |
| Montreal | 1.08 | 1.5 | 9 | 16 |
| Ottawa | 1.09 | 1.4 | 9 | 17 |
| Quebec | 1.08 | 1.5 | 13 | 28 |
| Regina | 1.02 | 1.5 | 7 | 8 |
| St. John's, Nfld | 1.14 | 1.4 | 17 | 20 |
| Saskatoon | 1.11 | 1.5 | 7 | 15 |
| Sault Ste. Marie | 1.14 | 1.6 | 16 | 23 |
| Toronto | 1.13 | 1.5 | 4 | 13 |
| Vancouver | 1.28 | 1.6 | 13 | 51 |
| Windsor | 1.17 | 1.6 | 4 | 14 |
| Winnipeg | 1.09 | 1.5 | 8 | 23 |
| Average | 1.12 | 1.5 | 11 | 22 |

## 3. Pan American Milk Sampling Program December 1967

*Pan American Health Organization* and *U.S. Public Health Service*

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (*5*).


**Figure 4. Pan American Milk Sampling Program stations**

Table 7 presents stable potassium, strontium–90 and cesium–137 monthly concentrations for December 1967.

**Table 7. Stable element and radionuclide concentration in PAHO milk,[a] December 1967**

| Sampling stations | Number of samples | Potassium (g/liter) | Strontium-90 (pCi/liter) | Cesium-137 (pCi/liter) |
|---|---|---|---|---|
| Chile: Santiago | 1 | 1.5 | <1 | 5 |
| Colombia: Bogota | 1 | 1.5 | 1 | <5 |
| Ecuador: Guayaquil | 1 | 1.5 | <1 | <5 |
| Jamaica: Montego Bay | 1 | 1.5 | 8 | 330 |
| Venezuela: Caracas | [b] 1 | 1.4 | 2 | 5 |
| | 1 | 1.5 | <1 | 10 |
| Canal Zone: Cristobal [c] | 4 | 1.5 | 2 | 12 |
| Puerto Rico: San Juan [c] | 3 | 1.6 | 5 | 6 |

[a] Strontium-89 was less than 5 pCi/liter and iodine-131 and barium-140 were less than 10 pCi/liter for all samples.
[b] Sample for November 1967.
[c] For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico, from the Pasteurized Milk Network are presented.

## REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, September 1967. Radiol Health Data Rep 9:20–23 (January 1968).
(*2*) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, October 1967. Radiol Health Data Rep 9:86–89 (February 1968).
(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).
(*4*) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian Milk Network, August 1966. Radiol Health Data Rep 7:702–703 (December 1966).
(*5*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704–705 (December 1966).

## State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows the States which report milk surveillance activities in *Radiological Health Data and Reports*. States having programs appearing in this issue are highlighted in the figure. Following is a summary of previously covered State programs, their reporting period, and issue of appearance.

| State milk network | Period reported | Last presented |
|---|---|---|
| California | July–September 1967 | March 1968 |
| Connecticut | July–September 1967 | February 1968 |
| Indiana | July–September 1967 | February 1968 |
| Iowa | July–September 1967 | February 1968 |
| Michigan | July–September 1967 | February 1968 |
| Minnesota | July–September 1967 | February 1968 |
| New York | April–June 1967 | November 1967 |
| Oregon | July–September 1967 | March 1968 |
| Pennsylvania | July–September 1967 | February 1968 |
| Washington | July–September 1967 | March 1968 |

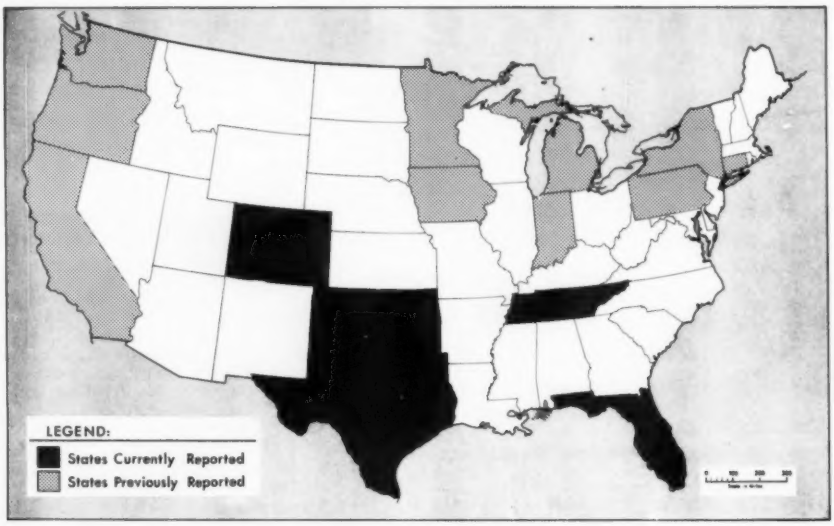


**Figure 1. Reported State milk programs**

---

### 1. Colorado Milk Network October–December 1967

*Air, Occupational and Radiation Hygiene Division*
*Colorado State Department of Public Health*

The Radiation Hygiene Section of the Colorado State Health Department initated analysis of milk for gamma-ray emitting radionuclides in January 1962. Initially, a composite milk sample from the major producers supplying the Denver area was collected by the Denver City and County Health Department for the State.

In August 1962, the State expanded this program to include the sampling of raw milk from the major milk producing areas supplying the entire State. The routine sampling rate depends on the activities of the Milk, Food and Drug Section of the State Health Department. Milkshed areas are shown in figure 2.

Analyses are performed for iodine–131, barium-lanthanum–140, cesium–137 and potassium by gamma-ray spectrometry. Employed in this procedure is a 4 by 5-inch diameter NaI (Tl) crystal housed in a modified office safe lined with 2 inches of lead and a 512 multichannel pulse-height analyzer using a typewriter readout. Samples and backgrounds are counted for

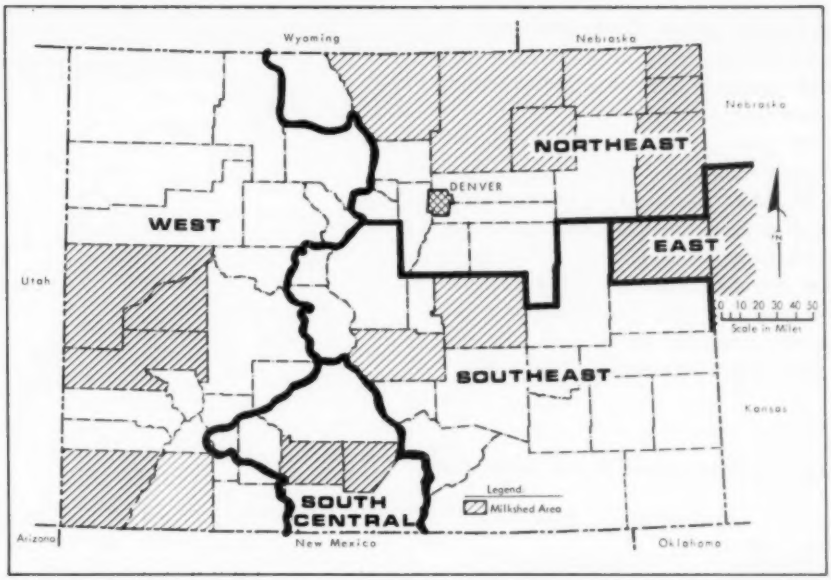


**Figure 2. Colorado milk sampling stations**

40 minutes in a 2 quart (1892 ml) plexiglass Marinelli beaker. Calculation is by the matrix method (*1*) and the minimum detectable concentrations are: iodine–131, 15 pCi/liter; barium-lanthanum–140, 21 pCi/liter; cesium–137, 16 pCi/liter; and potassium, 0.3 g/liter.

Eleven milk samples were collected and counted during the period from October 1, 1967, to December 31, 1967. Sampling was somewhat intensified in areas 3, 4, and 5, prior to and following the Gasbuggy shot of December 10, 1967. Iodine–131, barium-lanthanum–140 and cesium–137 were below the respective minimum detectable concentrations in all samples. Potassium concentration averaged $1.6 \pm 0.3$ ($2\sigma$) g/liter.

Recent coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| April–June 1967 | October 1967 |
| July–September 1967 | January 1967 |

## 2. Florida Milk Network October–December 1967

*Division of Radiological Health*
*Florida State Board of Health*

The Florida State Board of Health began sampling raw milk for iodine–131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the analysis of milk for strontium–89, strontium–90, cesium–137, barium–140 and potassium, in addition to iodine–131. Monthly samples are taken from randomly selected farms in each of the six regions shown in figure 3. A regional State Board of Health Laboratory is located in each of the six regions. Each laboratory prepares a monthly composite milk sample for its region by combining samples from 10 percent of the dairy farms selected at random. These composite samples are then sent to the State Radiological Health Laboratory in Orlando for analysis. In the interest of maintaining an active standby capability, samples are also collected and analyzed for iodine–131 on a monthly basis using the resin cartridge technique (*2*). Milk produced in the counties comprising each area is generally processed, marketed, and consumed in that area. These areas are characterized by differences in dairying practices related to the gradual transition from small farms in the west Florida

region, where locally grown feeds are used, to larger farms in the southern areas, where different types of grass and predominately purchased feeds are used.

Strontium–89 and strontium–90 are determined by the ion exchange method developed by Porter *et al.* (*3*). Iodine–131, cesium–137, barium–140 and potassium are determined by gamma-ray spectrometry (*4*).

Radionuclide concentration levels for October through December 1967, are presented in table 1. Strontium–89 analyses have been discontinued since 1965 due to extremely low levels.

Recent coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| January–June 1967 and summary for 1966 | October 1967 |
| July–September 1967 | January 1968 |


**Figure 3. Florida milk sampling areas**

**Table 1. Stable element and radionuclide concentrations in Florida raw milk October–December 1967**

| Sampling location | Concentration (g/liter) | | | Radionuclide concentration (pCi/liter) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Potassium | | | Strontium-90 | | | Iodine-131 | | | Cesium-137 | | | Barium-140 | | |
| | Oct | Nov | Dec | Oct | Nov | Dec | Oct | Nov | Dec | Oct | Nov | Dec | Oct | Nov | Dec |
| West | 1.6 | 1.5 | 1.2 | 16 | 18 | 12 | ND | ND | ND | 23 | 36 | 36 | 21 | ND | ND |
| North | 1.7 | 1.3 | 1.5 | 16 | 21 | 15 | ND | 30 | ND | 60 | 48 | 35 | 25 | ND | ND |
| Northeast | 1.6 | 1.6 | 1.6 | 10 | NA | 10 | ND | ND | ND | 125 | 84 | 98 | 24 | ND | 24 |
| Central | 1.7 | (a) | (a) | 9 | 9 | (a) | ND | (a) | (a) | 108 | (a) | (a) | ND | (a) | (a) |
| Tampa Bay area | 1.5 | 1.4 | 1.4 | 7 | 11 | 7 | ND | ND | ND | 104 | 101 | 79 | 21 | 34 | ND |
| Southeast | 1.4 | 1.4 | 1.4 | 9 | 7 | 9 | ND | ND | 24 | 108 | 114 | 96 | ND | ND | 24 |

[a] Insufficient sample.
ND, nondetectable.

## 3. Oklahoma Milk Network October–December 1967

*Oklahoma State Department of Health* [1]

On March 15, 1965, the Radiological Health Section of the Oklahoma State Department of Health initiated a program of analysis for iodine–131 in the milk produced in the State of Oklahoma. On March 7, 1966, analysis for cesium–137 was added to the program.

The location of the sampling stations and the extent of their associated milksheds are shown in figure 3. Of the ten milksheds in the State of Oklahoma, five were chosen as sampling stations (Oklahoma City, Enid, Tulsa, Lawton, and Ardmore) on the basis of their size and location. A major criterion in the selection of a milkshed for sampling was the degree of overlap with other milksheds being sampled.

[1] Acknowledgement is accorded to the staff of the Radiological Health Section under the direction of Mr. Dale McHard, head, and Mr. Robert Craig, assistant engineer.

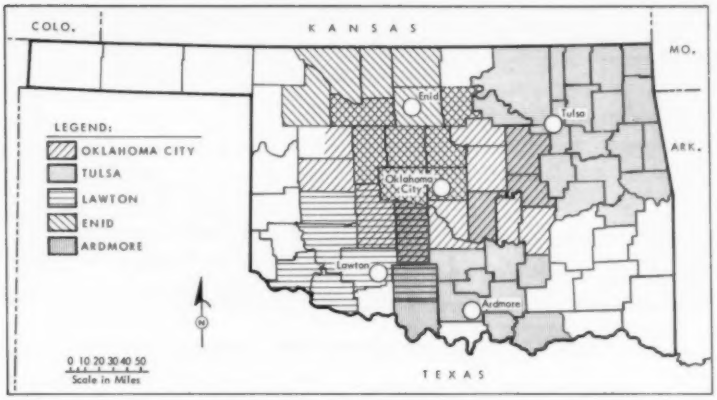


**Figure 4. Oklahoma milkshed sampling areas**

This overlap assists in locating small areas of production where the concentration of radioactivity might be abnormally high.

The sampling stations are located in the laboratory of a major milk-processing plant in each milkshed. While the milkshed for a particular processing plant may not coincide exactly with that shown in figure 3, the coincidence is satisfactory for surveillance purposes.

*Analytical method*

The method of analysis is similar to that recently published by the U.S. Public Health Service (*5*) but was developed independently by the Oklahoma State Health Department's Radiological Health Laboratory and has not been published to date. Details of the procedure used were published earlier (*6*).

**Table 2. Concentration of cesium–137 in Oklahoma pasteurized milk, October–November 1967**

| Sampling date | Concentration (pCi/liter) | | | | |
|---|---|---|---|---|---|
| | Sampling location | | | | |
| | Oklahoma City | Enid | Tulsa | Lawton | Ardmore |
| 1967 | | | | | |
| October 16 | 16 | ND | 16 | ND | 14 |
| October 20 | ND | 15 | ND | ND | 13 |
| October 27 | ND | ND | ND | ND | ND |
| November 13 | ND | ND | ND | ND | ND |
| November 30 | 11 | ND | 10 | ND | ND |

ND, nondetectable.

*Results and discussion*

The concentrations of iodine–131 found in Oklahoma milk were less than the minimum detectable concentration of 3 pCi/liter. Cesium–137 concentrations are presented in table 2. The minimum detectable concentration for cesium–137 is 10 pCi/liter.

Recent coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| April–June 1967 | October 1967 |
| July–September 1967 | January 1968 |

## 4. Tennessee Milk Network October–December 1967

*Division of Preventable Diseases*
*Department of Public Health, State of Tennessee*

The Tennessee Department of Public Health began sampling pasteurized milk for radionuclide analysis in July of 1965. Currently the Department is collecting semimonthly milk samples from three cities (figure 4). In order to obtain a representative sample of the milk consumed in the areas monitored, a sample of

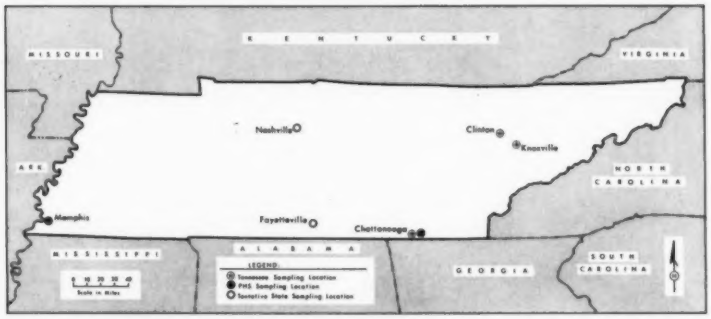


**Figure 5. Tennessee pasteurized milk sampling areas**

milk is collected from each distributor supplying the city. The samples from the individual distributors are then composited in proportion to the contribution each makes to the total city milk supply.

*Analytical procedures*

The semimonthly milk samples from each city sampled are analyzed by gamma-ray scintillation spectrometry for iodine–131, cesium–137, and barium–140, using a 3½-liter sample (*7*). After gamma-ray analysis, the samples are stored for 2 weeks to allow in-growth of daughter radioactivity, after which strontium–89, strontium–90, and barium–140 concentrations are determined radiochemically using ion-exchange procedures. Chemical analyses are also made for stable potassium.

The Chattanooga milk sample is monitored by both the State and the Public Health Service's Southeastern Radiological Health Laboratory. This dual examination of aliquot samples provides a crosscheck between the two laboratories.

*Results*

The monthly average stable element and radionuclide concentrations in Tennessee pasteurized milk are presented in table 3 for the period of October through December 1967.

Recent coverage in ***Radiological Health Data and Reports:***

| Period | Issue |
|---|---|
| April–June 1967 | October 1967 |
| July–September 1967 | January 1968 |

**Table 3. Radionuclides in Tennessee pasteurized milk, October–December 1967**

| Location | Month 1967 | Concentration (g/liter) | Radionuclide concentration (pCi/liter) | | | | |
|---|---|---|---|---|---|---|---|
| | | Potassium | Strontium-89 | Strontium-90 | Iodine-131 | Cesium-137 | Barium-140 |
| Chattanooga | Oct. | 1.4 | 7 | 18 | <8 | 15 | <5 |
| | Nov. | 1.4 | <5 | 14 | <8 | 14 | <5 |
| | Dec. | 1.4 | <5 | 16 | <8 | 14 | <5 |
| Clinton | Oct. | NS | NS | NS | NS | NS | NS |
| | Nov. | NS | NS | NS | NS | NS | NS |
| | Dec. | 1.4 | <5 | 13 | 19 | 26 | <5 |
| Knoxville | Oct. | 1.3 | <5 | 15 | <8 | 8 | <5 |
| | Nov. | 1.3 | 7 | 15 | <8 | 9 | <5 |
| | Dec. | 1.5 | <5 | 14 | <8 | 20 | <5 |

NS, no sample collected.

## 5. Texas Milk Network October–December 1967

*Texas State Department of Health* [2]

The Texas State Department of Health initiated a Statewide milk sampling network for radionuclide content in April 1964. At present, monthly samples of raw milk are collected from each of seven "active" sampling points. In addition, six "standby" stations are collecting raw milk samples once each calendar quarter. The station locations shown in figure 5 were chosen to give maximum geographical and population coverage.

Samples are routinely analyzed for strontium–90 by a chemical separation technique employing ion exchange columns (*8*). Prepared samples are counted for 100 minutes in a low-background beta-particle counter.

Potassium–40, iodine–131, barium–140 and cesium–137 concentrations are determined by gamma-ray spectrometry. The procedure employs a 4- by 4-inch sodium iodide crystal and a 400-channel analyzer. Samples are counted for 100 minutes in a 3.5 liter Marinelli beaker. The matrix method of calculation is used and detection limits at the 95-percent confidence level are 10 pCi/liter.

### *Results*

Potassium–40, strontium–90 and cesium–137 results by station and month for October through December 1967 are presented in table 4. During this time, the iodine–131, and barium–140 concentrations were below their limits of detectability (10 pCi/liter). A summary of radionuclide concentrations in Texas milk for the period from April 1964 through December 1967 is presented in figure 6.

Comparison of the observed radionuclide concentrations with the Federal Radiation Council guides for peacetime operation indicates that at no time during the period of surveillance did the radionuclide concentrations in Texas milk approach levels suggesting any remedial action (*9*).

[2] Acknowledgement is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, chief engineer.

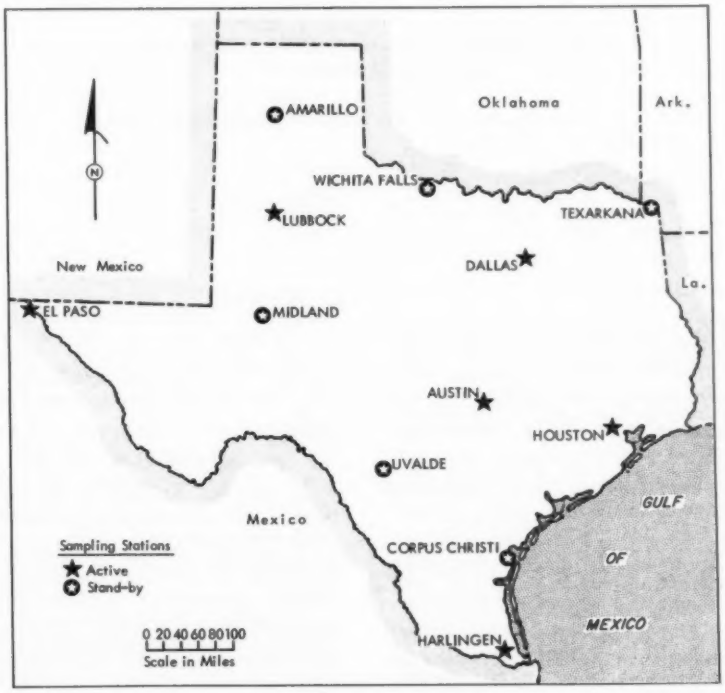


**Figure 6. Texas milk sampling stations**

**Table 4. Radionuclide concentrations in Texas raw milk network October–December 1967**

| Sampling location | Radionuclide concentration (pCi/liter) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Potassium-40 | | | Strontium-90 | | | Cesium-137 | | |
| | Oct | Nov | Dec | Oct | Nov | Dec | Oct | Nov | Dec |
| Austin [a] | | | | | | | | | |
| Fort Worth | 1,290 | 1,230 | 1,260 | 5 | 5 | 4 | 5 | 10 | 5 |
| El Paso | 1,320 | 1,330 | 1,280 | 1 | 1 | 2 | 5 | 5 | 5 |
| Harlingen | 1,300 | 1,330 | 1,370 | 2 | 3 | 2 | 5 | 5 | 5 |
| Houston | 1,320 | 1,320 | 1,350 | 12 | 7 | 11 | 10 | 5 | 5 |
| Lubbock | 1,250 | 1,320 | 1,360 | 3 | 3 | 4 | 5 | 5 | 5 |
| San Antonio | 1,370 | 1,320 | 1,350 | 3 | 2 | 4 | 5 | 5 | 5 |
| Average | 1,310 | 1,310 | 1,330 | 4 | 3 | 4 | 5 | 5 | 5 |

[a] Austin, Tex., discontinued sampling October 1, 1967.

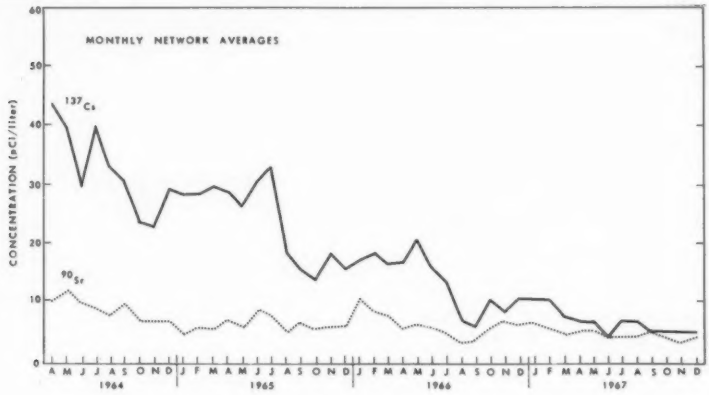


**Figure 7. Radionuclide concentrations in Texas milk, April 1964–December 1967**

Recent coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| April–June 1967 | October 1967 |
| July–September 1967 | January 1968 |

## REFERENCES


(1) COLORADO STATE DEPARTMENT OF PUBLIC HEALTH, OCCUPATIONAL AND RADIOLOGICAL HEALTH DIVISION. Colorado milk network, October–December 1964 and summary 1962–1964. Radiol Health Data 6:202–204 (April 1965); January 1965–June 1966. Radiol Health Data Rep 7:573–575 (October 1966).

(2) INDIANA STATE BOARD OF HEALTH, BUREAU OF ENVIRONMENTAL SANITATION. Indiana milk network, April–June 1965. Radiol Health Data 6:612–614 (November 1965).

(3) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Improved determination of strontium-90 in milk by ion-exchange method. Anal Chem 33:1306–1309 (September 1961).

(4) FLORIDA STATE BOARD OF HEALTH, DIVISION OF RADIOLOGICAL HEALTH. Florida milk network, July–December 1964. Radiol Health Data 6:611–612 (November 1965).

(5) PORTER, C. R., and M. W. CARTER. Field method for rapid collection of iodine-131 from milk. Public Health Rep 80:453–456 (May 1965).

(6) OKLAHOMA STATE DEPARTMENT OF HEALTH. Oklahoma milk network, October–December 1966. Radiol Health Data Rep 8:203–204 (April 1967).

(7) PORTER, C., R. AUGUSTINE, J. MATUSEK, Jr., and M. CARTER. Procedures for determining stable nuclides and elements in environmental samples, PHS No. 999–RH–10. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (January 1965).

(8) PORTER, C., and B. KAHN. Improved determination of strontium-90 in milk by ion exchange method. Anal Chem 36:676–678 (March 1964).

(9) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

## Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Periodically, results from the United Kingdom Diet survey conducted by the United Kingdom Agricultural Research Council Radiobiological Laboratory, are presented for comparison with data observed in the United States. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows.

| Program | Period reported | Last presented |
|---|---|---|
| California Diet Study | March–June 1967 | February 1968 |
| Connecticut Standard Diet | January–June 1967 | November 1967 |
| Tri-City Diet, HASL | January–March 1967 | March 1968 |

---

### 1. Radionuclides in Institutional Diet Samples July–September 1967

*National Center for Radiological Health*
*Public Health Service*

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the National Center for Radiological Health with the assistance of the National Center for Urban and Industrial Health (*1*).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 basic institutions, distributed geographically as shown in figure 1, were being sampled. Previous results show that the daily dietary intake

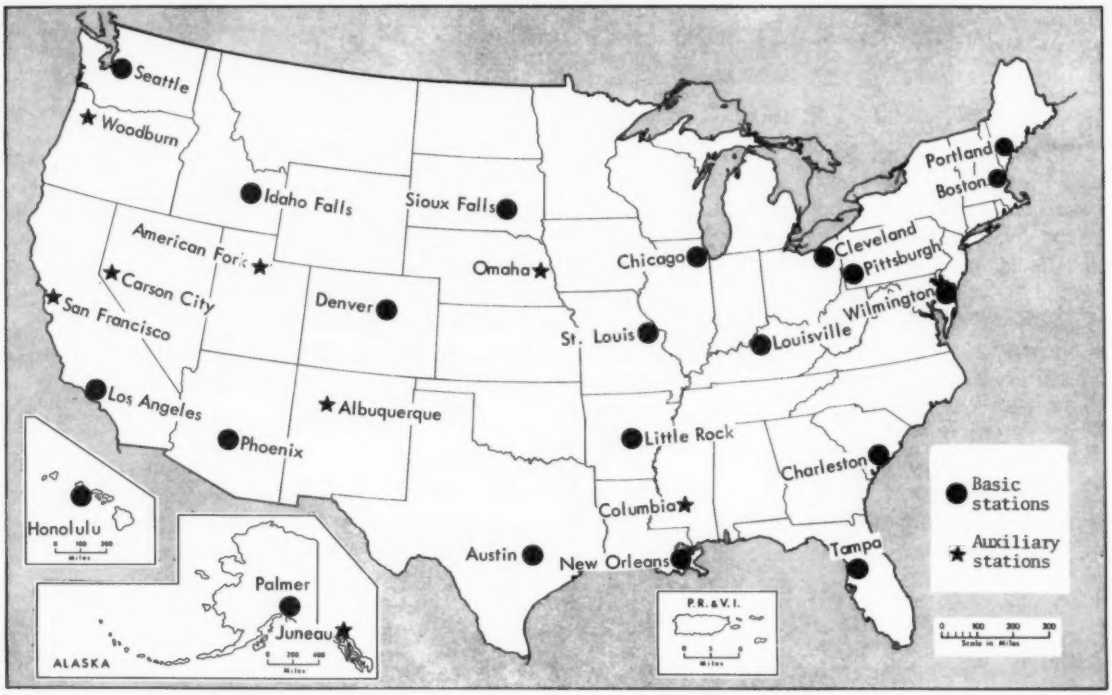


**Figure 1. Institutional diet sampling locations as of September 1967**

of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1*, *2*). Consequently, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample supplied monthly by each institution represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period, and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev., the Southeastern Radiological Health Laboratory, Montgomery, Ala., or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented earlier (*3*).

*Results*

Table 1 presents the analytical results for institutional diet samples collected from July through September 1967, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of these samples, reported in pCi/kg of diet, are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes, in g/day or pCi/day, were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.84 kg/day compared to the network average of 1.90 kg/day observed from 1961 through 1964 (*4*).

Strontium–90 dietary intake during this period averaged 14 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (*5*). Cesium–137 intakes averaged 28 pCi/day during this period. Strontium–89, barium–140 and iodine–131 concentrations were generally below detectable levels.

**Table 1. Concentrations and intake of stable elements and radionuclides in Institutional total diets in children (9-12 years of age), July–September 1967**

| Location of Institution | | Month | Total weight (kg/day) | Calcium | | Potassium | | Strontium-90 | | Cesium-137 | | Radium-226 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | g/kg | g/day | g/kg | g/day | pCi/kg | pCi/day | pCi/kg | pCi/day | pCi/kg | pCi/day |
| Alaska: | Palmer | July | 1.59 | 0.5 | 0.8 | 1.3 | 2.1 | 5 | 8 | 25 | 40 | 0.4 | 0.6 |
| | | Aug | 1.62 | .4 | .6 | 1.2 | 1.9 | 5 | 8 | 20 | 32 | .6 | 1.0 |
| | | Sept | 1.54 | .7 | 1.1 | 1.6 | 2.4 | 12 | 18 | 47 | 72 | .7 | 1.1 |
| Aris: | Phoenix | July | 2.19 | .8 | 1.8 | 1.6 | 3.6 | 4 | 8 | 15 | 33 | .6 | 1.3 |
| | | Aug | 2.07 | .8 | 1.7 | 1.4 | 2.9 | 3 | 6 | 11 | 23 | 1.1 | 2.3 |
| | | Sept | 1.99 | .6 | 1.2 | 1.5 | 3.0 | 8 | 15 | 11 | 22 | .6 | 1.2 |
| Ark: | Little Rock | July | 1.25 | .6 | .7 | 1.7 | 2.1 | 20 | 25 | 15 | 19 | .8 | 1.0 |
| | | Aug | 1.76 | .5 | 1.1 | 1.9 | 3.4 | 17 | 30 | 17 | 30 | .7 | 1.2 |
| | | Sept | 2.12 | .6 | 1.2 | 1.9 | 4.1 | 15 | 32 | 23 | 49 | .5 | 1.1 |
| Calif: | Los Angeles | July | 2.03 | .5 | 1.1 | 1.3 | 2.6 | 4 | 7 | 0 | 0 | .4 | .8 |
| | | Aug | 1.92 | .5 | 1.0 | 1.6 | 3.0 | 6 | 12 | 12 | 23 | .6 | 1.2 |
| | | Sept | 1.99 | .5 | .9 | 1.3 | 2.5 | 4 | 7 | 12 | 23 | .6 | 1.1 |
| Colo: | Denver | July | 2.99 | .7 | 2.1 | 1.6 | 4.8 | 6 | 18 | 15 | 45 | .7 | 2.1 |
| | | Aug | 2.37 | .6 | 1.5 | 1.6 | 3.7 | 6 | 13 | 13 | 31 | .5 | 1.1 |
| | | Sept | 2.35 | .6 | 1.5 | 1.3 | 3.1 | 4 | 10 | 11 | 26 | .8 | 1.9 |
| Del: | Wilmington | July | 2.38 | .8 | 1.9 | 1.8 | 4.3 | 16 | 14 | 17 | 40 | .8 | 1.9 |
| | | Aug | 2.20 | .7 | 1.5 | 1.9 | 4.1 | 9 | 20 | 14 | 31 | .5 | 1.1 |
| | | Sept | 2.22 | .7 | 1.5 | 1.8 | 4.1 | 10 | 21 | 0 | 0 | .7 | 1.6 |
| Fla: | Tampa | July | 1.94 | .6 | 1.1 | 1.9 | 3.7 | 5 | 10 | 61 | 118 | .7 | 1.4 |
| | | Aug [b] | 2.06 | .6 | 1.3 | 1.8 | 3.7 | 7 | 15 | 43 | 89 | .8 | 1.6 |
| | | Sept [b] | 2.09 | .6 | 1.2 | 1.8 | 3.8 | 9 | 19 | 55 | 115 | .9 | 1.9 |
| Hawaii: | Honolulu | July | 2.05 | .4 | .9 | 1.6 | 3.2 | 0 | 0 | 0 | 0 | .6 | 1.2 |
| | | Aug [b] | 1.62 | .4 | .6 | 1.2 | 1.9 | 5 | 8 | 20 | 32 | .6 | 1.0 |
| | | Sept [b] | 1.91 | .3 | .5 | 1.3 | 2.6 | 4 | 7 | 18 | 35 | .2 | .4 |
| Idaho: | Idaho Falls | July [b] | 1.87 | 1.4 | 2.6 | 1.7 | 3.1 | 6 | 11 | 12 | 22 | 1.7 | 3.2 |
| | | Aug [b] | 2.05 | 1.2 | 2.5 | 2.0 | 4.1 | 14 | 30 | 26 | 53 | .8 | 1.6 |
| | | Sept [b] | 1.83 | 1.4 | 2.6 | 1.7 | 3.2 | 9 | 16 | 0 | 0 | .4 | .7 |
| Ill: | Chicago | July | 1.33 | .7 | .9 | 1.6 | 2.2 | 7 | 9 | 22 | 29 | .9 | 1.2 |
| | | Aug [b] | 1.64 | .8 | 1.2 | 1.6 | 2.6 | 8 | 13 | 18 | 30 | .5 | .8 |
| | | Sept [b] | 1.63 | .6 | 1.1 | 1.6 | 2.7 | 5 | 8 | 11 | 18 | .7 | 1.1 |
| Ky: | Louisville | July | 1.76 | .8 | 1.4 | 1.6 | 2.8 | 8 | 14 | 0 | 0 | .7 | 1.2 |
| | | Aug | 1.73 | .7 | 1.2 | 1.6 | 2.7 | 9 | 16 | 14 | 24 | 1.4 | 2.4 |
| | | Sept [b] | 2.28 | .5 | 1.1 | 1.6 | 3.6 | 7 | 15 | 0 | 0 | .7 | 1.6 |
| La: | New Orleans | July | 1.96 | .6 | 1.3 | 1.7 | 3.3 | 11 | 22 | 25 | 49 | .4 | .8 |
| | | Aug | 2.26 | .7 | 1.7 | 1.6 | 3.6 | 12 | 27 | 22 | 50 | .4 | .9 |
| | | Sept | 2.06 | .8 | 1.6 | 1.7 | 3.5 | 13 | 26 | 26 | 54 | .8 | 1.6 |
| Mass: | Boston | July | 1.70 | .7 | 1.2 | 1.6 | 2.8 | 11 | 19 | 32 | 54 | .5 | .8 |
| | | Aug | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | | Sept | 2.08 | .7 | 1.5 | 1.8 | 3.8 | 10 | 21 | 19 | 40 | .7 | 1.5 |
| Mo: | St. Louis | July | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| | | Aug | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| | | Sept | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Ohio: | Cleveland | July | 1.43 | .6 | .8 | 2.0 | 2.8 | 8 | 11 | 0 | 0 | .9 | .7 |
| | | Aug | 1.46 | .6 | .8 | 1.9 | 2.8 | 8 | 12 | 12 | 18 | .9 | 1.3 |
| | | Sept | 1.31 | .7 | .9 | 1.9 | 2.5 | 5 | 6 | 0 | 0 | 1.9 | 2.5 |
| Pa: | Pittsburgh | July [b] | 2.20 | .6 | 1.2 | 1.5 | 3.4 | 6 | 14 | 16 | 35 | .7 | 1.5 |
| | | Aug | 2.30 | .6 | 1.3 | 1.6 | 3.6 | 7 | 16 | 0 | 0 | .6 | 1.4 |
| | | Sept | 2.25 | .5 | 1.2 | 1.5 | 3.4 | 7 | 16 | 20 | 45 | .6 | 1.4 |
| S. C: | Charleston | July | 1.61 | .6 | 1.0 | 1.7 | 2.8 | 9 | 14 | 46 | 74 | 1.1 | 1.8 |
| | | Aug | 1.54 | .5 | .8 | 1.5 | 2.3 | 8 | 12 | 26 | 40 | 1.3 | 2.0 |
| | | Sept [b] | 2.00 | .6 | 1.2 | 1.5 | 3.1 | 11 | 22 | 21 | 42 | 1.0 | 2.0 |
| S. Dak: | Sioux Falls | July | 1.26 | .7 | 1.0 | 1.7 | 2.0 | 7 | 9 | 0 | 0 | .7 | .9 |
| | | Aug | 1.18 | .7 | .8 | 1.8 | 2.2 | 7 | 8 | 0 | 0 | .9 | 1.1 |
| | | Sept | 1.31 | .6 | .7 | 1.7 | 2.2 | 5 | 6 | 0 | 0 | .2 | .3 |
| Tex: | Austin | July | 1.88 | .6 | 1.0 | 1.5 | 2.9 | 3 | 6 | 0 | 0 | .6 | 1.1 |
| | | Aug | 1.53 | .6 | .9 | 1.3 | 2.0 | 8 | 12 | 0 | 0 | 1.4 | 2.1 |
| | | Sept | 1.63 | .6 | .9 | 1.4 | 2.2 | 5 | 8 | 0 | 0 | .6 | 1.0 |
| Vt: | Burlington [a] | July | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| | | Aug | 1.63 | .8 | .9 | 1.8 | 2.4 | 16 | 24 | 26 | 38 | 1.3 | 1.9 |
| | | Sept | 1.40 | .7 | 1.0 | 1.6 | 2.3 | 12 | 17 | 25 | 35 | .7 | 1.0 |
| Wash: | Seattle | July [b] | 1.92 | NA | NA | 1.8 | 3.3 | NA | NA | 18 | 34 | NA | NA |
| | | Aug [b] | 2.23 | .9 | 2.0 | 1.1 | 2.5 | 7 | 15 | 0 | 0 | .3 | .7 |
| | | Sept [b] | 1.89 | .6 | 1.0 | 1.3 | 2.5 | 6 | 12 | 20 | 28 | .5 | .9 |
| Institutional average | | July | 1.83 | 0.6 | 1.2 | 1.6 | 3.0 | 7 | 12 | 17 | 31 | 0.7 | 1.2 |
| | | Aug | 1.83 | 0.6 | 1.1 | 1.6 | 2.9 | 9 | 16 | 13 | 24 | 0.9 | 1.5 |
| | | Sept | 1.87 | 0.6 | 1.2 | 1.6 | 3.0 | 8 | 16 | 15 | 28 | 0.7 | 1.3 |

[a] Institution change in August 1967 from Burlington, Vt. to Portland, Maine.
[b] Since food samples were collected from two or more children who were not between the ages of 9 to 12, data for this month were not used in institutional average.
NA, no analysis.
NS, no sample.

NOTE: Since iodine-131 and barium-140 were not detectable at most stations during the third quarter 1967, no provision was made for these nuclides in the table. The few exceptions are as follows: barium-140 was reported in July for Washington, 14 pCi/kg; in August for Hawaii, 16 pCi/kg, and in September for Arizona, 18 pCi/kg.

In past issues minimum detectable concentrations have been presented as less than values. Beginning with this issue all concentrations that are less than or equal to the appropriate minimum detectable level will be reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable limits are as follows:

| | |
|---|---|
| Strontium–89 | 5 pCi/kg |
| Strontium–90 | 2 pCi/kg |
| Iodine–131 | 10 pCi/kg |
| Barium–140 | 10 pCi/kg |
| Cesium–137 | 10 pCi/kg |
| Radium–226 | 0.1 pCi/kg |

Beginning with this issue, data from eight auxiliary stations will be included in a separate table for general information. This is presented in table 2. These stations do not meet the criteria that the majority of the children in the institution range in age from 9 to 12 years. In order to supplement the existing environmental monitoring networks of the National Center for Radiological Health, these eight institutions are also being sampled in the same manner as the basic stations.

Recent coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| October–December 1966 | July 1967 |
| April–June 1967 | January 1968 |

**Table 2. Concentrations and intake of stable elements and radionuclides in Institutional total diets of individuals, July–September 1967 (auxiliary stations)**

| Location of Institution | Month | Total weight (kg/day) | Calcium | | Potassium | | Strontium-90 | | Cesium-137 | | Radium-226 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | g/kg | g/day | g/kg | g/day | pCi/kg | pCi/day | pCi/kg | pCi/day | pCi/kg | pCi/day |
| Alaska: Juneau | July | 2.32 | 0.2 | 0.6 | 1.0 | 2.3 | 3 | 7 | 0 | 0 | 0.4 | 0.9 |
| | Aug | 3.10 | .3 | .8 | 0.9 | 2.7 | 3 | 8 | 0 | 0 | .3 | .9 |
| | Sept | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| Calif: San Francisco | July | 2.84 | .9 | 2.7 | 1.5 | 4.2 | 6 | 17 | 19 | 54 | 2.1 | 6.0 |
| | Aug | 2.07 | .5 | 1.1 | 1.8 | 3.7 | 3 | 6 | 11 | 23 | .8 | 1.7 |
| | Sept | 1.83 | .8 | 1.5 | 1.5 | 2.8 | 6 | 11 | 15 | 27 | .9 | 1.6 |
| Miss: Columbia | July | 2.39 | .9 | 2.2 | 1.5 | 3.6 | 6 | 15 | 18 | 43 | .7 | 1.4 |
| | Aug | 2.22 | .9 | 2.0 | 1.7 | 3.8 | 10 | 22 | 20 | 44 | .9 | 2.0 |
| | Sept | 1.79 | .8 | 1.5 | 1.4 | 2.5 | 9 | 16 | 20 | 36 | .8 | 1.4 |
| Nebr: Omaha | July | 2.18 | 1.2 | 2.7 | 1.8 | 4.0 | 6 | 13 | 11 | 24 | 1.2 | 2.6 |
| | Aug | 2.39 | .8 | 1.9 | 1.8 | 4.3 | 8 | 18 | 0 | 0 | .6 | 1.4 |
| | Sept | 2.23 | .8 | 1.7 | 1.8 | 4.1 | 6 | 14 | 15 | 33 | .9 | 2.0 |
| Nev: Carson City | July | 1.36 | .7 | .9 | 1.7 | 2.3 | 5 | 7 | 20 | 27 | 1.0 | 1.4 |
| | Aug | 1.77 | .9 | 1.7 | 1.6 | 2.9 | 4 | 8 | 0 | 0 | 1.4 | 2.5 |
| | Sept | 1.88 | .6 | 1.2 | 1.7 | 3.2 | 6 | 11 | 17 | 32 | .8 | 1.5 |
| N. Mex: Albuquerque | July | 2.45 | .8 | 2.1 | 1.9 | 4.6 | 0 | 0 | 0 | 0 | .5 | 1.2 |
| | Aug | 2.30 | .8 | 2.0 | 1.7 | 4.0 | 5 | 11 | 0 | 0 | .5 | 1.2 |
| | Sept | 2.49 | .8 | 1.9 | 1.6 | 4.0 | 6 | 16 | 0 | 0 | .5 | 1.2 |
| Ore: Woodburn | July | 2.36 | .6 | 1.4 | 1.9 | 4.5 | 5 | 12 | 17 | 40 | .7 | 1.6 |
| | Aug | 2.41 | .6 | 1.5 | 1.8 | 4.4 | 5 | 13 | 21 | 51 | .7 | 1.7 |
| | Sept | 2.33 | .6 | 1.4 | 1.7 | 4.0 | 4 | 10 | 20 | 47 | .6 | 1.4 |
| Utah: American Fork | July | 1.97 | .6 | 1.2 | 1.3 | 2.5 | 4 | 7 | 11 | 22 | .5 | 1.0 |
| | Aug | 1.89 | .6 | 1.1 | 1.1 | 2.1 | 4 | 8 | 0 | 0 | .5 | .9 |
| | Sept | 1.92 | .6 | 1.1 | 1.2 | 2.2 | 4 | 7 | 11 | 21 | .1 | .2 |
| Institutional average | July | 2.23 | 0.7 | 1.7 | 1.6 | 3.5 | 4 | 10 | 12 | 26 | 0.9 | 2.0 |
| | Aug | 2.27 | 0.7 | 1.5 | 1.6 | 3.5 | 5 | 12 | 6 | 15 | 0.7 | 1.5 |
| | Sept | 2.07 | 0.7 | 1.5 | 1.6 | 3.3 | 6 | 12 | 14 | 28 | 0.7 | 1.3 |

NA, no analysis.
NS, no sample.

REFERENCES


(1) ANDERSON, E. C., and D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(2) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Radiol Health Data 6:548–554 (October 1965).

(3) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, April–June 1965. Radiol Health Data 7:92–98 (February 1966).

(4) GRUNDY, R. D., C. CALVERT, and A. G. BERGER. Summary of results of Institutional Total Diet Sampling Network, 1961–1964. Radiol Health Data 6:691–698 (December 1965).

(5) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

# SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence [1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

| Water sampling program | Period reported | Last presented |
|---|---|---|
| California | July–December 1966 | February 1968 |
| Coast Guard | January–December 1966 | November 1967 |
| Minnesota Municipal | January–June 1967 | January 1968 |
| New York Surface | January–May 1967 | January 1968 |
| Washington Surface | July 1965–June 1966 | August 1967 |

REFERENCES


(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

# Gross Radioactivity in Surface Waters of the United States, October 1967

*Division of Pollution Surveillance, Federal Water Pollution Control Administration Department of Interior*

The monitoring of levels of radioactivity in surfaces waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the August 1967 issue of *Radiological Health Data and Reports.*

During October, the following stations decreased to less than 15 pCi/liter for suspended solids;

Arkansas River; Ponca City, Okla.
Kansas River; DeSoto, Kans.
Rio Grande; Laredo, Tex.
San Juan River; Shiprock, N. Mex.
Yellowstone River; Sidney, Mont.

No station in October showed a beta radioactivity of more than 150 pCi/liter.

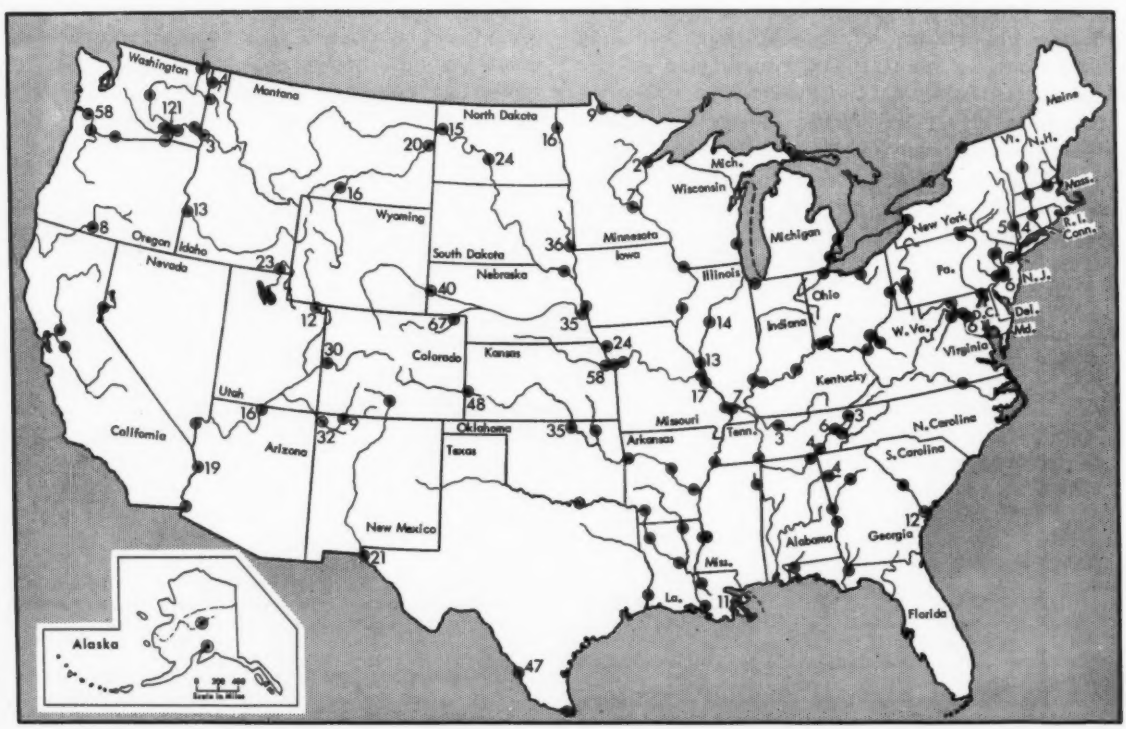


**Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, October 1967**

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During September and October, the following stations showed values in excess of 15 pCi/liter on alpha radioactivity for either suspended or dissolved solids:

Arkansas River; Coolidge, Kans.
North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

During October, Loma, Colo., on the Colorado River showed a value in excess of 15 pCi/liter on alpha radioactivity for suspended solids.

**Table 1. Radioactivity in raw surface waters, October 1967**

| Station | Average alpha radioactivity (pCi/liter) | | | Average beta radioactivity (pCi/liter) | | |
|---|---|---|---|---|---|---|
| | Suspended | Dissolved | Total | Suspended | Dissolved | Total |
| Animas River: | | | | | | |
| Cedar Hill, N. Mex. | 0 | 2 | 2 | 1 | 8 | 9 |
| Arkansas River: | | | | | | |
| Coolidge, Kans. | 2 | 20 | 22 | 7 | 41 | 48 |
| Ponca City, Okla. | 8 | 2 | 10 | 23 | 12 | 35 |
| Bear River: | | | | | | |
| Preston, Idaho | 1 | 1 | 2 | 6 | 17 | 23 |
| Big Horn River: | | | | | | |
| Hardin, Mont. | 0 | 5 | 5 | 1 | 15 | 16 |
| Big Sioux River: | | | | | | |
| Sioux Falls, S. Dak. | <1 | 4 | 4 | 4 | 32 | 36 |
| Clearwater River: | | | | | | |
| Lewiston, Idaho | 0 | 0 | 0 | 1 | 2 | 3 |
| Clinch River: | | | | | | |
| Clinton, Tenn. | 0 | 0 | 0 | 0 | 3 | 3 |
| Kingston, Tenn.* | 0 | 0 | 0 | 0 | 6 | 6 |
| Colorado River: | | | | | | |
| Loma, Colo. | 2 | 16 | 18 | 5 | 25 | 30 |
| Page, Ariz. | 0 | 4 | 4 | 1 | 15 | 16 |
| Parker Dam, Calif.-Ariz. | 0 | 7 | 7 | 1 | 18 | 19 |
| Columbia River: | | | | | | |
| Pasco, Wash.* | 0 | 1 | 1 | 8 | 113 | 121 |
| Clatskanie, Ore. | 0 | <1 | <1 | 8 | 50 | 58 |
| Connecticut River: | | | | | | |
| Enfield Dam, Conn. | 0 | 0 | 0 | 1 | 3 | 4 |
| Coosa River: | | | | | | |
| Rome, Ga. | 1 | <1 | 1 | 1 | 3 | 4 |
| Cumberland River: | | | | | | |
| Cheatham Lock, Tenn. | 0 | 0 | 0 | 1 | 2 | 3 |
| Delaware River: | | | | | | |
| Philadelphia, Pa. | 0 | 0 | 0 | 1 | 5 | 6 |
| Great Lakes: | | | | | | |
| Duluth, Minn. | 0 | 0 | 0 | 0 | 2 | 2 |
| Green River: | | | | | | |
| Dutch John, Utah | 0 | 3 | 3 | 0 | 12 | 12 |
| Hudson River: | | | | | | |
| Poughkeepsie, N. Y. | 0 | 0 | 0 | 1 | 4 | 5 |
| Illinois River: | | | | | | |
| Peoria, Ill. | 1 | 1 | 2 | 5 | 9 | 14 |
| Grafton, Ill. | 1 | 2 | 3 | 4 | 9 | 13 |
| Kansas River: | | | | | | |
| DeSoto, Kans. | 11 | 1 | 12 | 45 | 13 | 58 |
| Klamath River: | | | | | | |
| Keno, Ore. | 0 | 0 | 0 | <1 | 8 | 8 |
| Mississippi River: | | | | | | |
| St. Paul, Minn. | 0 | 0 | 0 | 1 | 6 | 7 |
| E. St. Louis, Ill. | 2 | 1 | 3 | 7 | 10 | 17 |
| New Orleans, La. | 0 | 1 | 1 | 2 | 9 | 11 |
| Missouri River: | | | | | | |
| Williston, N. Dak. | 0 | 4 | 4 | 2 | 13 | 15 |
| Bismarck, N. Dak. | 3 | 3 | 6 | 10 | 14 | 24 |
| St. Joseph, Mo. | 1 | 4 | 5 | 8 | 16 | 24 |
| North Platte River: | | | | | | |
| Henry, Nebr. | <1 | 26 | 26 | 3 | 37 | 40 |
| Ohio River: | | | | | | |
| Cairo, Ill. | 0 | 0 | 0 | 1 | 6 | 7 |
| Pend Oreille River: | | | | | | |
| Albeni Falls Dam, Idaho | 0 | 1 | 1 | <1 | 4 | 4 |
| Platte River: | | | | | | |
| Plattsmouth, Nebr. | 6 | 6 | 12 | 14 | 21 | 35 |
| Potomac River: | | | | | | |
| Washington, D. C. | 0 | 0 | 0 | 1 | 5 | 6 |
| Rainy River: | | | | | | |
| Baudette, Minn. | 0 | 1 | 1 | 2 | 7 | 9 |
| Red River, North: | | | | | | |
| Grand Forks, N. Dak. | 0 | 1 | 1 | 1 | 15 | 16 |
| Rio Grande: | | | | | | |
| El Paso, Tex. | 0 | 5 | 5 | 2 | 19 | 21 |
| Laredo, Tex. | 10 | 3 | 13 | 36 | 11 | 47 |
| San Juan River: | | | | | | |
| Shiprock, N. Mex. | 7 | 4 | 11 | 24 | 8 | 32 |
| Snake River: | | | | | | |
| Payette, Idaho | 0 | 6 | 6 | <1 | 13 | 13 |
| South Platte River: | | | | | | |
| Julesburg, Colo. | 3 | 37 | 40 | 10 | 57 | 67 |
| Tennessee River: | | | | | | |
| Chattanooga, Tenn. | 0 | 0 | 0 | <1 | 4 | 4 |
| Yellowstone River: | | | | | | |
| Sidney, Mont. | 3 | 4 | 7 | 9 | 11 | 20 |
| Maximum | 11 | 37 | 40 | 45 | 113 | 121 |
| Minimum | 0 | 0 | 0 | 0 | 2 | 2 |

* Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

REFERENCES

(1) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(2) *Ibid.*, 1959 Edition.
(3) *Ibid.*, 1960 Edition.
(4) *Ibid.*, 1961 Edition.
(5) *Ibid.*, 1962 Edition.
(6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(7) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–12 (January 1968).

# Radiostrontium in Tap Water, January-June 1967[1]

*Health and Safety Laboratory*
*U.S. Atomic Energy Commission*

The Health and Safety Laboratory has performed analyses for strontium–90 in tap water at New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Cesium–137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

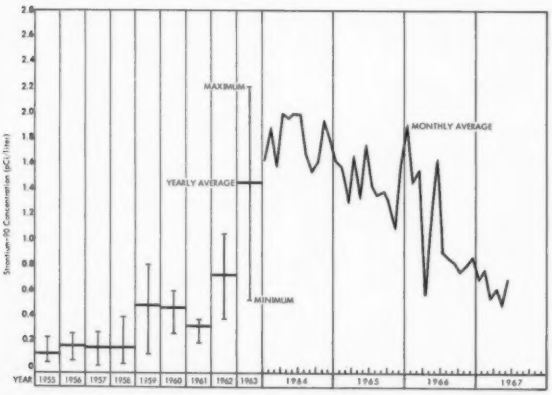


**Figure 1. Strontium–90 concentrations in New York City tap water, 1955–June 1967**

**Table 1. Radiostrontium in New York City tap water January–June 1967**

| Date 1967 | Strontium-90 [a] (pCi/liter) | Cesium-137/ strontium-90 ratios |
|---|---|---|
| January | 0.71 | 0.06 |
| February | .76 | .05 |
| March | .55 | .07 |
| April | .61 | .10 |
| May | .50 | .12 |
| June | .70 | .08 |

[a] Approximately 100 liters per sample.

Strontium–90 concentration and cesium–137/strontium–90 ratios in New York City tap water for January through June 1967 are presented in table 1. These results appear graphically in figure 1.

A decreasing trend has been observed in the strontium–90 concentrations since the July 1963 peak. The maximum strontium–90 concentrations observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (*2*).

REFERENCES

(1) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures 40:E–38–01–16. Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York 14, N.Y.
(2) FEDERAL REGISTER RULES AND REGULATIONS. Title 42–Public Health, Chapter 1, Public Health Service, Department of Health, Education and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards 27:2154–2155. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

Recent coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| July–December 1966 | November 1967 |

[1] Prepared from information appearing in Fallout Program Quarterly Summary Report, HASL–184. This report is available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

# SECTION III. AIR AND DEPOSITION

## Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-particle analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

| Network | Period | Issue |
|---|---|---|
| HASL 80th Meridian Network | January–June 1967 | March 1968 |
| Plutonium in Airborne Particulates | April–June 1967 | November 1967 |

## 1. Radiation Alert Network December 1967

*National Center for Radiological Health*
*U.S. Public Health Service*

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate and dried precipitation samples and report the results to appropriate NCRH officials by mail or telephone, depending on levels found. Compilation of the daily field estimates is reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during December 1967. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

Concentrations of radioactive particulates in surface air were at normal levels until the last week of the month when a brief rise occurred at most stations. Table 2 lists 5-hour field estimates on air samples reported that were in excess of 15 pCi/m$^3$. Table 3 lists air samples that were identified as containing fresh fission product radioactivity.


**Figure 1. Radiation Alert Network sampling stations**

## Table 1. Gross beta radioactivity in surface air and precipitation, December 1967

| Station location | | Number of samples | | Air surveillance | | | Last profile in RHD & R | Precipitation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Gross beta radioactivity (pCi/m³) | | | | Total depth (mm) | Field estimation of deposition [b] | | |
| | | Air | Pptn | Maximum | Minimum | Average [a] | | | Number samples | Depth (mm) | Total deposition (nCi/m²) |
| Ala: | Montgomery | 31 | 12 | 9.98 | 0.15 | 1.51 | Nov 67 | 149 | 3 | 52 | 1 |
| Alaska: | Adak | 7 | ------- | .36 | .36 | .36 | Apr 68 | ([d]) | | | |
| | Anchorage | 16 | 7 | .46 | .00 | .04 | Dec 67 | 26 | 7 | 26 | 6 |
| | Attu Island | 6 | ------- | .41 | .00 | .05 | July 67 | ([d]) | | | |
| | Fairbanks | ([c]) | ------- | ------- | ------- | ------- | Jan 68 | ([d]) | | | |
| | Juneau | 21 | 12 | .38 | .00 | .03 | Feb 68 | 149 | 12 | 149 | 23 |
| | Kodiak | 21 | ------- | 5.11 | .00 | .41 | Mar 68 | ([d]) | | | |
| | Nome | 10 | ------- | .77 | .00 | .26 | Sept 67 | ([d]) | | | |
| | Pt. Barrow | 31 | ------- | .64 | .61 | .61 | Aug 67 | ([d]) | | | |
| | St. Paul Island | 30 | ------- | 1.31 | .44 | .53 | Oct 67 | ([d]) | | | |
| Ariz: | Phoenix | 23 | ------- | 22.42 | .19 | 5.95 | Feb 68 | ([d]) | | | |
| Ark: | Little Rock | 18 | 9 | 1.11 | .11 | .43 | Dec 67 | 157 | 2 | 31 | 0 |
| Calif: | Berkeley | 24 | 5 | 5.69 | .00 | .75 | Mar 68 | 57 | 5 | 57 | 0 |
| | Los Angeles | 24 | 5 | 7.50 | .25 | .95 | Sept 67 | 55 | 5 | 55 | 0 |
| C. Z: | Ancon | 6 | ------- | ------- | ------- | ------- | Mar 68 | ([d]) | | | |
| Colo: | Denver | 22 | 2 | 18.12 | .39 | 3.15 | Mar 68 | 6 | 0 | 0 | ([c]) |
| Conn: | Hartford | 22 | 8 | 1.08 | .00 | .27 | Jan 68 | 126 | 8 | 126 | 105 |
| Del: | Dover | 21 | ------- | 3.82 | .00 | .50 | Nov 67 | ([d]) | | | |
| D. C: | Washington | 30 | 10 | 9.52 | .22 | 1.06 | Aug 67 | 148 | 10 | 148 | 58 |
| Fla: | Jacksonville | 21 | 6 | 9.75 | .00 | 1.01 | Dec 67 | 112 | 3 | 47 | 0 |
| | Miami | 21 | 4 | .26 | .06 | .17 | Jan 68 | 35 | 4 | 35 | 0 |
| Ga: | Atlanta | 16 | 9 | 8.95 | .82 | 1.92 | Oct 67 | 165 | 9 | 165 | 95 |
| Guam: | Agana | 6 | ------- | ------- | ------- | ------- | Nov 67 | ([d]) | | | |
| Hawaii: | Honolulu | 31 | 5 | 1.19 | .30 | .45 | July 67 | 144 | 0 | 0 | ([c]) |
| Idaho: | Boise | 24 | 6 | 11.09 | .34 | 1.83 | July 67 | 9 | 5 | 8 | 0 |
| Ill: | Springfield | 20 | 9 | 1.59 | .00 | .50 | Aug 67 | 148 | 0 | 0 | |
| Ind: | Indianapolis | 21 | 11 | 6.83 | .23 | .91 | Oct 67 | 134 | 11 | 134 | 116 |
| Iowa: | Iowa City | 20 | 1 | 4.32 | .91 | 1.72 | Mar 68 | 7 | 1 | 7 | 0 |
| Kans: | Topeka | 22 | 5 | 6.95 | .25 | .88 | Dec 67 | 47 | 5 | 47 | 31 |
| Ky: | Frankfort | 11 | 5 | 1.36 | .58 | .86 | Aug 67 | 34 | 5 | 34 | 143 |
| La: | New Orleans | 21 | 7 | 2.65 | .00 | .25 | Aug 67 | 249 | 0 | 0 | ([c]) |
| Maine: | Augusta | 22 | 10 | 1.19 | .00 | .28 | Feb 68 | 163 | 10 | 163 | 13 |
| Md: | Baltimore | 22 | 5 | .75 | .00 | .38 | Jan 68 | 50 | 5 | 50 | 18 |
| | Rockville | 9 | [d] 1 | .48 | .01 | .06 | July 67 | 89 | 0 | 0 | ([c]) |
| Mass: | Lawrence | 22 | 6 | .85 | .00 | .20 | Nov 67 | 142 | 2 | 65 | 56 |
| | Winchester | 20 | 7 | 4.41 | .00 | .32 | Apr 68 | 121 | 7 | 121 | 0 |
| Mich: | Lansing | 21 | ------- | 1.99 | .22 | .71 | July 67 | ([d]) | | | |
| Minn: | Minneapolis | 21 | 4 | .78 | .19 | .30 | Nov 67 | 9 | 4 | 9 | 0 |
| Miss: | Jackson | 17 | 6 | 1.18 | .00 | .37 | Feb 68 | 194 | 6 | 194 | 165 |
| Mo: | Jefferson City | 22 | 10 | 1.83 | .14 | .35 | Oct 67 | 74 | 10 | 74 | 1 |
| Mont: | Helena | 22 | 8 | 1.38 | .23 | .58 | Apr 68 | 28 | 8 | 28 | 31 |
| Nebr: | Lincoln | 20 | 3 | 6.66 | .68 | 2.28 | Oct 67 | 16 | 3 | 16 | 0 |
| Nev: | Las Vegas | 22 | ------- | 4.70 | .15 | 1.20 | Jan 68 | ([d]) | | | |
| N. H: | Concord | 21 | ------- | 2.23 | .00 | .48 | Aug 67 | ([d]) | | | |
| N. J: | Trenton | 20 | 4 | 4.92 | .00 | .56 | Feb 68 | 66 | 4 | 66 | 23 |
| N. Mex: | Sante Fe | 21 | 5 | 9.86 | .18 | 1.07 | Apr 68 | 53 | 5 | 53 | 4 |
| N. Y: | Albany | 23 | 11 | 2.11 | .20 | .57 | Oct 67 | 75 | 10 | 75 | 124 |
| | Buffalo | ([c]) | ------- | ------- | ------- | ------- | Mar 68 | ([d]) | | | |
| | New York | 22 | ------- | 4.93 | .13 | .40 | Apr 68 | ([d]) | | | |
| N. C: | Gastonia | 17 | 5 | 10.46 | .55 | 3.49 | Mar 68 | 55 | 0 | 0 | ([c]) |
| N. Dak: | Bismarck | 22 | 3 | 4.25 | .29 | 1.46 | Aug 67 | 10 | 3 | 10 | 0 |
| Ohio: | Cincinnati | 16 | ------- | 6.88 | .40 | 1.18 | Nov 67 | ([d]) | | | |
| | Columbus | 20 | 7 | 1.17 | .12 | .42 | Feb 68 | 50 | 5 | 44 | 0 |
| | Painesville | 22 | 9 | 6.29 | .13 | .59 | Jan 68 | 46 | 9 | 46 | 51 |
| Okla: | Oklahoma City | 19 | 1 | 5.84 | .37 | 1.06 | July 67 | 12 | 1 | 12 | 12 |
| | Ponca City | 23 | 4 | 4.93 | .23 | .83 | Jan 68 | 29 | 4 | 29 | 18 |
| Ore: | Portland | 23 | 15 | 2.98 | .00 | .33 | Oct 67 | 89 | 15 | 89 | 0 |
| Pa: | Harrisburg | 16 | 1 | 6.92 | .41 | 1.23 | Oct 67 | 45 | 0 | 0 | |
| P. R: | San Juan | 10 | 1 | .00 | .00 | .00 | Feb 68 | 28 | 1 | 28 | 0 |
| R. I: | Providence | 21 | 4 | 3.11 | .00 | .36 | July 67 | 124 | 2 | 53 | 19 |
| S. C: | Columbia | 6 | 2 | 2.92 | .00 | .41 | Apr 68 | 22 | 0 | 0 | |
| S. Dak: | Pierre | 14 | ------- | 8.10 | 1.14 | 3.25 | Feb 68 | ([d]) | | | |
| Tenn: | Nashville | 17 | 9 | .99 | .28 | .59 | July 67 | 132 | 9 | 132 | 0 |
| Tex: | Austin | 16 | 3 | 6.00 | .37 | 1.77 | Nov 67 | 66 | 0 | 0 | ([c]) |
| | El Paso | 30 | 3 | 7.09 | .64 | 3.04 | Aug 67 | 20 | 3 | 20 | 0 |
| Utah: | Salt Lake City | 31 | 12 | 5.17 | .24 | .59 | Sept 67 | 47 | 7 | 20 | 10 |
| Vt: | Barre | 21 | 7 | 1.93 | .00 | .37 | Dec 67 | 73 | 7 | 73 | 27 |
| Va: | Richmond | 18 | 7 | 2.10 | .21 | .72 | Dec 67 | 130 | 3 | 64 | 10 |
| Wash: | Seattle | 6 | 14 | 27.95 | .00 | 8.20 | Dec 67 | 106 | 0 | 0 | ([c]) |
| | Spokane | 22 | 1 | 2.73 | .24 | .75 | Nov 67 | 1 | 1 | 1 | 0 |
| W. Va: | Charleston | 22 | 12 | 1.51 | .24 | .66 | Apr 68 | 113 | 12 | 113 | 150 |
| Wis: | Madison | 22 | 9 | 1.25 | .09 | .50 | Dec 67 | 48 | 9 | 48 | 42 |
| Wyo: | Cheyenne | 22 | 6 | 9.68 | .09 | 1.26 | Jan 68 | 11 | 6 | 11 | 11 |
| Network summary | | 1,388 | 352 | 27.95 | 0.00 | 1.02 | | 78 | 6 | 63 | 30 |

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] The data in these columns apply only to samples for which field estimates were made.
[c] Indicates no report received. (Air samples received without field estimate data are not considered by the data program.)
[d] Indicates no precipitation sample collected.
[e] Indicates the station is part of the plutonium in precipitation network. No gross beta measurements are done.

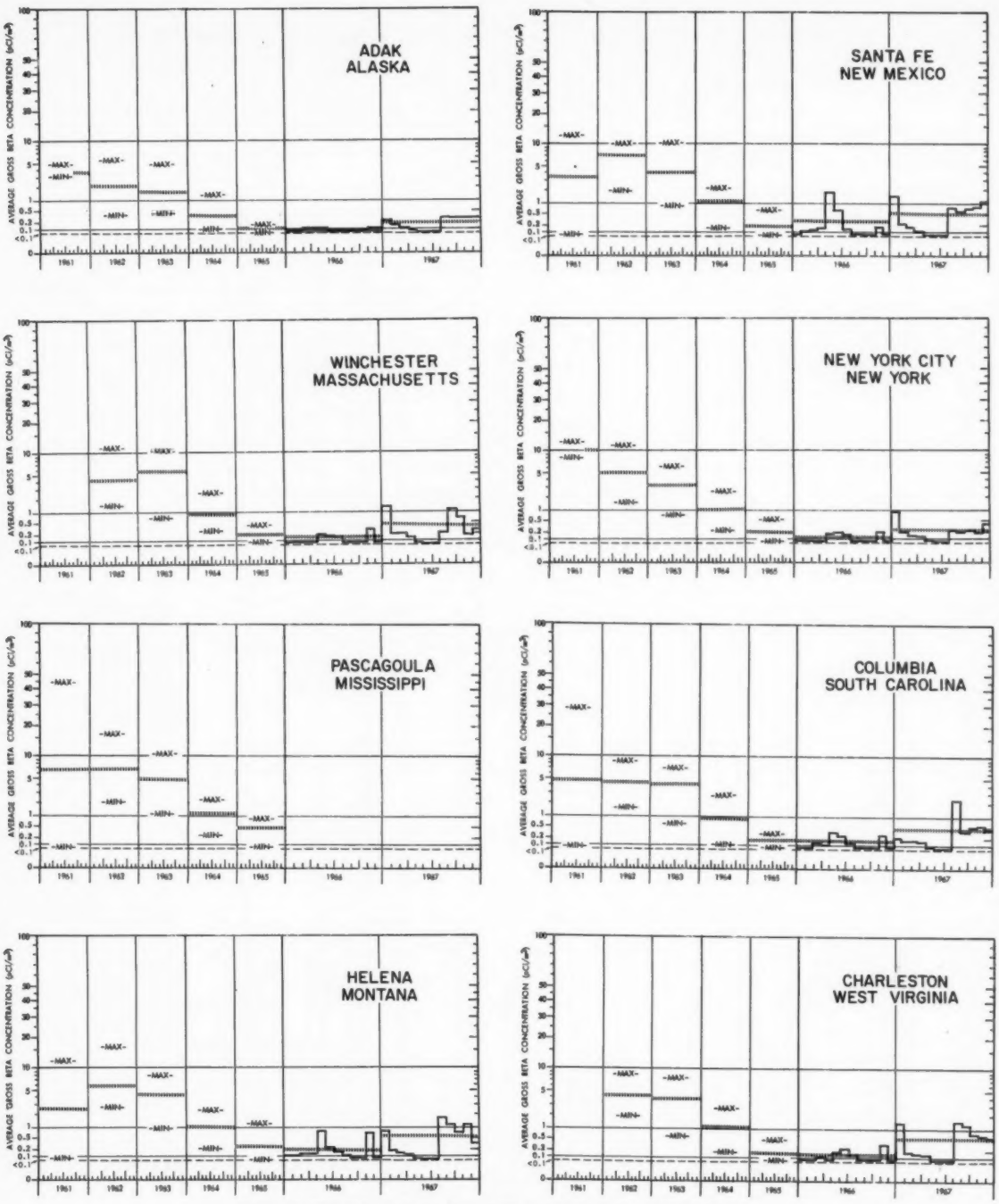


**Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1961–December 1967**

**Table 2. RAN air samples with gross beta radioactivity concentration greater than 15 pCi/m³ at 5 hours after collection**

| Location | Collection date | 5-hour field estimate (pCi/m³) |
|---|---|---|
| Denver, Colo | 12/28/67 | 18.12 |
| Phoenix, Aris | 12/5/67 | *22.42 |
| | 12/30/67 | 20.23 |
| Seattle, Wash | 12/30/67 | 26.83 |
| | 12/31/67 | 27.95 |

* Believed to be due to natural radioactivity. Decayed to 0.41 pCi/m³ in 24 hours. No evidence of fresh fission products.

**Table 3. RAN air samples in which fresh fission products were identified by gamma-ray spectroscopy***

| Date (1967) | Location | |
|---|---|---|
| 12/28 | Utah: | Salt Lake |
| | Wyo: | Cheyenne |
| | Alaska: | Kodiak |
| 12/29 | N. Mex: | Santa Fe |
| | Colo: | Denver |
| 12/30 | Ala: | Montgomery |
| | Kans: | Topeka |
| | Okla: | Oklahoma City |
| | Colo: | Denver |
| | Idaho: | Boise |
| | Calif: | Berkeley |
| | Wash: | Seattle |
| 12/31 | D.C. | Washington |
| | Fla: | Jacksonville |
| | Ga: | Atlanta |
| | Ala: | Montgomery |
| | Ind: | Indianapolis |
| | Ohio: | Cincinnati |
| | | Painesville |
| | Nebr: | Lincoln |
| | Calif: | Berkeley |
| | Wash: | Seattle |

* These samples, when scanned, showed the presence of short-lived iodines and barium-lanthanum-140.

## 2. Canadian Air and Precipitation Monitoring Program [1] December 1967

*Radiation Protection Division*
*Department of National Health and Welfare*

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations (figure 3) are located at airports, where the sampling equipment is operated by personnel from the Meteorologic Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

### *Air sampling procedure and results*

Each air sample involves the collection of particulates from about 650-cubic meters of air drawn through a high efficiency 4-inch diameter glass-fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa for analysis.

To determine the beta radioactivity, a 2-inch diameter disk is cut from each filter and counted with a thin-end window, gas flow,

**Table 4. Canadian gross beta radioactivity in surface air and precipitation, December 1967**

| Station | Number of samples | Air surveillance gross beta radioactivity (pCi/m³) | | | Precipitation measurements | |
|---|---|---|---|---|---|---|
| | | Maximum | Minimum | Average | Average concentrations (pCi/liter) | Total deposition (nCi/m²) |
| Calgary | 31 | 1.2 | 0.0 | 0.1 | NS | NS |
| Coral Harbour | 31 | 0.1 | .0 | .0 | 9 | 0.2 |
| Edmonton | 31 | 3.3 | .0 | .2 | 696 | 27.7 |
| Fr. Churchill | 31 | .1 | .0 | .0 | 7 | .1 |
| Ft. William | 31 | .2 | .0 | .0 | 370 | 10.4 |
| Fredericton | 17 | .2 | .0 | .0 | 42 | 8.5 |
| Goose Bay | 31 | 3.5 | .0 | .1 | 16 | 1.4 |
| Halifax | 31 | .6 | .0 | .0 | 16 | 3.9 |
| Inuvik | 31 | .1 | .0 | .0 | 13 | .2 |
| Montreal | 31 | 1.5 | .0 | .1 | 177 | 16.6 |
| Moosonee | 31 | .5 | .0 | .1 | 10 | .4 |
| Ottawa | 31 | .5 | .0 | .0 | 25 | 1.4 |
| Quebec | 31 | 2.7 | .0 | .2 | 84 | 9.1 |
| Regina | 31 | 1.6 | .0 | .1 | 59 | .9 |
| Resolute | 31 | .1 | .0 | .0 | 3 | .2 |
| St. John's, Nfld | 31 | .2 | .0 | .0 | 58 | 4.3 |
| Saskatoon | 31 | 3.4 | .0 | .1 | 117 | 2.7 |
| Saulte Ste Marie | 31 | 0.3 | .0 | .0 | 23 | 2.2 |
| Toronto | 30 | .5 | .0 | .1 | 12 | .9 |
| Vancouver | 31 | 17.9 | .0 | .7 | 39 | 5.1 |
| Whitehorse | 31 | .2 | .0 | .0 | 18 | .3 |
| Windsor | 31 | .2 | .0 | .0 | 13 | 2.0 |
| Winnipeg | 31 | 5.3 | .0 | .2 | 88 | 1.9 |
| Yellowknife | 31 | .1 | .0 | .0 | 17 | .2 |
| Network summary | 729 | 17.9 | 0.0 | 0.1 | 83 | 4.4 |

NS, no sample.

[1] Prepared from January 1968 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

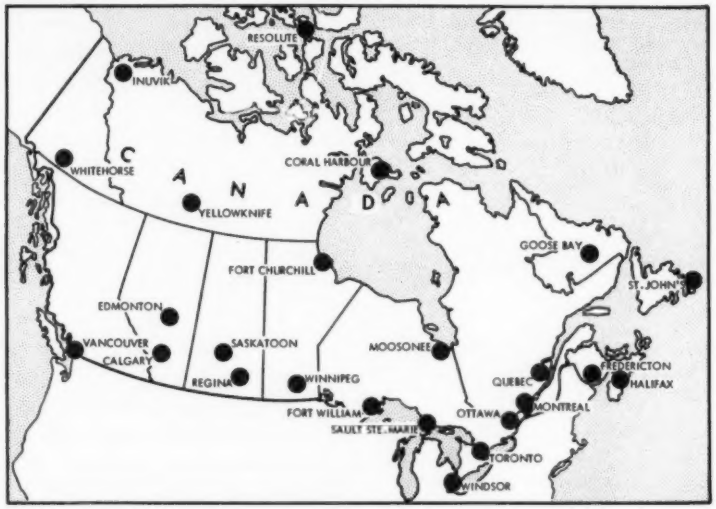


**Figure 3. Canadian air and precipitation sampling stations**

Geiger-Mueller counter system calibrated with a strontium-yttrium–90 standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for December 1967, are presented in table 2.

*Precipitation collection and analysis*

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is 1 month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are added to selected samples depending upon the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter together with the polyethylene liner is then ignited and ashed at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infrared lamp and then counted with a thin-end window Geiger-Mueller counter calibrated with a strontium-yttrium–90 source.

The monthly precipitation samples represent the total deposition of radioactive materials on the earth's surface. The December 1967 gross beta deposition values are given in table 4.

## 3. Mexican Air Monitoring Program December 1967

*National Commission of Nuclear Energy*

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada.


**Figure 4. Mexican air sampling locations**

Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Prevision del Golfo de Mexico, the Chemistry Department of the University of Merida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

*Sampling*

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20 hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (*7*).

The maximum, minimum, and average beta radioactivity in surface air during December 1967 are presented in table 5.

**Table 5. Mexican gross beta radioactivity of airborne particulates, December 1967**

| Station | Number of samples | Gross beta radioactivity (pCi/m³) | | |
|---|---|---|---|---|
| | | Maximum | Minimum | Average |
| Acapulco | 13 | 0.5 | 0.1 | 0.1 |
| Chihuahua | 4 | .3 | .1 | .2 |
| Ciudad Juarez | 15 | .2 | .1 | .1 |
| Ensenada | 3 | .1 | .1 | NS |
| Guadalajara | 11 | .1 | .1 | .1 |
| Guaymas | NS | NS | .1 | NS |
| La Paz | NS | NS | .1 | NS |
| Matamoros | NS | NS | .1 | NS |
| Mazatlán | 5 | .1 | .1 | .1 |
| Mérida | 6 | .3 | .1 | .1 |
| México, D. F. | 7 | 1.7 | .1 | .3 |
| Nuevo Laredo | NS | NS | .1 | NS |
| San Luis Potosí | NS | NS | .1 | NS |
| Tampico | 6 | .1 | .1 | .1 |
| Torreon | 13 | .2 | .1 | .1 |
| Veracruz | 9 | .1 | .1 | .1 |

NS, no sample collected, station temporarily shutdown.

## 4. Pan American Air Sampling Program December 1967

*Pan American Health Organization and U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the January 1968 *Radiological Health Data and Reports*. The December 1967 air monitoring results from the participating countries are given in table 6.

No fresh fission products were identified in the December samples.


Figure 5. Pan American Air Sampling Program stations

Table 6. PAHO gross beta radioactivity in surface air December 1967

| Station location | Number of samples | Gross beta radioactivity (pCi/m³) | | |
|---|---|---|---|---|
| | | Maximum | Minimum | Average |
| Argentina: Buenos Aires | [b] | | | |
| Bolivia: La Paz | 20 | 0.03 | 0.01 | 0.01 |
| Chile: Santiago | 30 | .06 | .00 | .03 |
| Colombia: Bogota | 19 | .03 | .00 | .01 |
| Ecuador: Guayaquil | 30 | .06 | .02 | .03 |
| Jamaica: Kingston | 19 | .05 | .00 | .02 |
| Peru: Lima | 3 | .05 | .03 | .03 |
| Venezuela: Caracas | 11 | .01 | .00 | .01 |
| West Indies: Trinidad | 11 | .02 | .00 | .01 |
| Pan American summary | 143 | 0.06 | 0.00 | 0.02 |

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
[b] No December samples received.

REFERENCES


(1) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Environmental radiation surveillance report. National Center for Radiological Health, Standards and Intelligence Branch, Rockville, Md. 20852 (Distribution by official request).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(3) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4, Department of National Health and Welfare, Ottawa, Canada (December 1962).

(4) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(5) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(6) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(7) VASQUEZ, M., and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963–1965. Comisión Nacional de Energía Nuclear, Dirección General de Seguridad Radiológica (in press 1966).

# SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

## Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Lawrence Radiation Laboratory and the Mound Laboratory.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

### 1. Lawrence Radiation Laboratory January–June 1967 [2]

*University of California*
*Berkeley, California*

*Berkeley site*

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is situated on the western slope of the range of hills running along the eastern side of San Francisco Bay. The laboratory area is largely separated from the main campus of the University, although there is some overlap.

To the north and south of the laboratory area are residential areas of the cities of Berkeley and Oakland. The Berkeley campus of the university of California is on the west; to the east is uninhabited watershed land and the Tilden Regional Park.

The most prevalent wind direction is westerly. During the summer months the afternoon sea breeze establishes a very pronounced prevailing westerly wind direction. At other times, the direction is less predictable. Annual rainfall is 23 inches, almost all of which falls between November 1 and May 1. The prevailing wind direction during precipitation is southerly.

The laboratory carries on a wide ranging program of general research in the fields of both physical and biological sciences. Facilities include a number of large accelerators, and vari-

[2] Summarized from "Results of Environmental Radioactivity Sampling Program, January–June 1967," Lawrence Radiation Laboratory, Livermore and Berkeley, Calif.

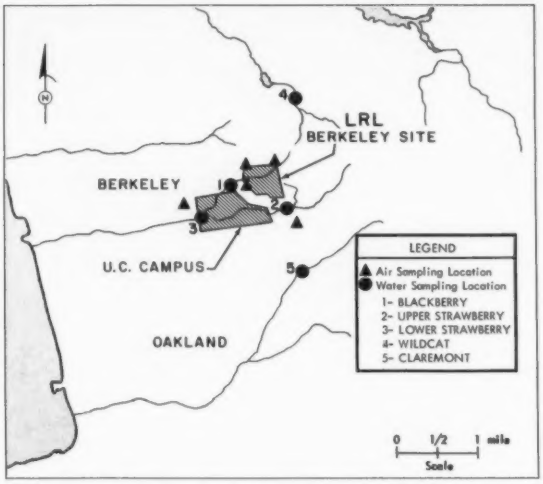


**Figure 1. Environmental sampling locations at the Berkeley site**

ous physics, chemistry, biology and medical research laboratories.

The basic policy at LRL has long been to prevent, as far as possible, any release of radioactive material to the environment, no matter how small. No deliberate releases are sanctioned, except where no practical method for containment has yet been developed and quantites are small compared with standards established by the ICRP and AEC.

The most sensitive measurements of releases are those taken closest to the source itself, before dilution makes detection of small quantities more difficult. The stack sampling program, therefore, provides the most useful information for controlling releases to the atmosphere. Over 100 separate exhausts from hoods and glove box manifolds are sampled. The total quantities released from these stacks during the 6 months were 0.4 microcuries alpha-particle and 600 microcuries of beta-particle emitters. The average concentrations in the total exhaust, before any dilution by the atmosphere, was 12 percent of the maximum permissible concentration for offsite breathing zone air, as given by the ICRP.

In addition to the careful sampling of stacks, an environmental air sampling program is also carried on to make sure no undetected releases occur. These samples provide a direct measurement of possible exposure to the nearby population. The sampling stations designated "local area" are scattered around the site and provide samples of the atmosphere on the site itself. The "perimeter" samples are taken at the boundary line of University property, in the direction of populated areas. From the results of these samples, it is apparent that there has been no significant exposure from radioactive materials released by LRL. The levels of radioactivity observed in each type of sample are presented in table 1.

**Table 1. Atmospheric monitoring, LRL Berkeley site January–June 1967**

| Sampling locations (number of locations) | Number of samples | Concentration (pCi/m³) | | | |
|---|---|---|---|---|---|
| | | Alpha radioactivity | | Beta radioactivity | |
| | | Average | Maximum | Average | Maximum |
| Local area (9) | 215 | 0.000 | 0.004 | 0.15 | 2.67 |
| Perimeter (4) | 102 | .000 | .004 | .33 | 5.25 |

**Table 2. Total deposition, LRL Berkeley site January–June 1967**

| Sampling locations (number of locations) | Number of samples | Deposition (nCi/m²) | | | |
|---|---|---|---|---|---|
| | | Alpha radioactivity | | Beta radioactivity | |
| | | Average | Maximum[a] | Average | Maximum |
| Local area (9) | 51 | 0.05 | 0.13 | 19.96 | 73.38 |
| Perimeter (4) | 24 | .12 | .22 | 31.96 | 57.94 |

[a] Maximum deposition at a single location for the 6-month period.

At each of these environmental stations rain or dry "fallout" is also collected. Open 15-inch diameter polyethylene bags form the collecting vessel. If no rain has fallen, the bags are rinsed out with dilute nitric acid. Results from these collections show a lot of variation, without any consistent pattern. Since on the average, the more remote perimeter stations show more radioactivity than the nearer ones, it must be assumed that the radioactivity does not result from laboratory operations.

All liquid waste known to be radioactive is collected, solidified, and shipped away. Other liquid wastes are discharged directly to the municipal sewer system. Small quantities of radioisotopes now and then are accidentally released to the sewer system. There are two

outfalls, each of which is monitored by a continuous proportional sampling system to insure that no significant quantities have been discharged. The total concentration (alpha-plus-beta radioactivity) in sewage is only 21 percent of the standard for drinking water and therefore does not constitute a serious exposure threat. A sizeable fraction of the measured beta concentration is the naturally occurring isotope, potassium–40 from human wastes and chemicals.

The storm drainage from the laboratory flows into the surface stream system. These surface streams are exposed as they run through the University property and are sampled at three places. Results are listed as "onsite streams" in the table. Two nearby offsite streams are also sampled to provide a comparison. No alarming concentrations have been observed. All are safely below the standard for drinking water. The results from the water sampling program are presented in table 3.

**Table 3. Water monitoring, LRL Berkeley site January–June 1967**

| Type and source of sample | Number of samples | Concentration (pCi/liter) | | | |
|---|---|---|---|---|---|
| | | Alpha radioactivity | | Beta radioactivity | |
| | | Average | Maximum | Average | Maximum |
| Sewage: | | | | | |
| Hearst sewer | 24 | 0.38 | 3.36 | 18.5 | 63.6 |
| Strawberry sewer | 24 | .47 | 1.94 | 14.0 | 47.4 |
| Tap water | 26 | .11 | | 2.43 | |
| Surface water: | | | | | |
| Onsite streams | 77 | .83 | 3.2 | 6.46 | 45.0 |
| Offsite streams | 52 | .66 | 3.3 | 2.85 | 23.7 |

Neutron and gamma-ray fields are measured at each of the four perimeter stations as well as at several locations within the site. Background measurements are obtained from a leased building used as a low level counting room in downtown Berkeley. This building is remote from the main LRL site and measurements are not influenced by accelerator operations.

There is a notable decrease at all of the monitoring sites for the 6-month period, January–June 1967, due to the shutdown of the bevatron for repair and modification. All sites are affected more or less by all machines. However, the bevatron is the largest source of radiation seen throughout the four stations except during certain operating conditions at the 88-inch cyclotron.

Improved shielding along the bevatron external beam line should limit the stray radiation to a somewhat lower value than previously noted, assuming similar beam currents.

Agriculture is the principal activity in the Livermore Valley. Roses, grain, hay, and grapes are the major products. Several cattle and sheep ranches surround the Livermore site.

*Livermore site*

The Livermore site of LRL (figure 2) is located in the Livermore Valley midway between the Pacific coast and the San Joaquin Valley in northern California—approximately 50 miles southeast of San Francisco. Shielded from the ocean by the western hills, the Livermore Valley has a warm, dry climate. Annual rainfall is about 14 inches and the relative humidity is about 30 percent during the summer months and about 40-50 percent the remainder of the year. Prevailing winds are from the west, but inversions are frequent during the night. Technical facilities include a small cyclotron, a 2-megawatt swimming pool reactor, and physics and chemistry programs associated with a weapons development program.

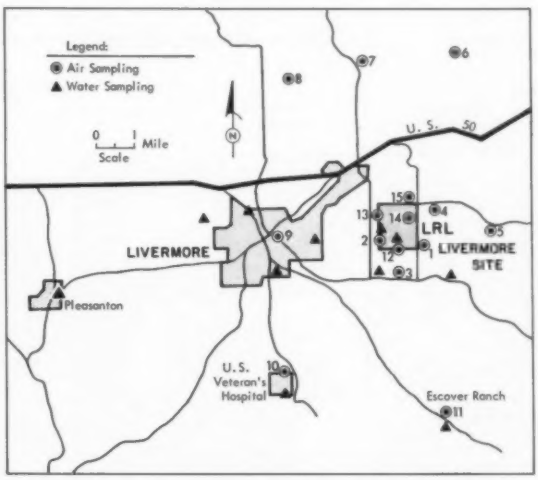


**Figure 2. Environmental sampling locations at the Livermore site**

The Livermore site comprises an area of 1 square mile, approximately 3 miles east of the city of Livermore. Livermore and Pleasanton, with a combined population of 45,000, are populated areas of primary interest to the Livermore site.

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, sewage plant products, milk, and vegetation. The milk samples are obtained from two dairies in the Livermore Valley and one in another valley about 25 miles away, which is used as a check. Air and soil samples are collected to ascertain that control efforts are restricting the release of radioactivity from the laboratory to levels which do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples are collected to monitor radioactivity in an underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton, and is the sole supply for ranches in the Livermore and Amador Valleys.

Air samples are collected continuously at 15 sites within 5 miles of the laboratory. Samples are collected at a rate of 4 cfm on 100-square centimeter HV–70 filter papers, which are changed after every 7 days of operation. A minimum decay period of 96 hours is observed before the samples are counted to eliminate the effect of natural radon and thoron daughters. All environmental air samples are counted in an automated system which utilizes gas flow proportional detectors for both alpha and beta radioactivity measurements. Alpha radioactivity in 362 air samples collected from 15 sampling locations averaged 0.0010 pCi/m³. The average beta radioactivity was higher than the average for last year—0.17 pCi/m³ (1967), versus 0.06 pCi/m³ (1966). The applicable AEC radiation protection standards are 0.040 pCi/m³ for alpha-particle emitters and 1 pCi/m³ for beta-particle emitters.

The measurement of low level "background" radiation during this period was accomplished with thermoluminescent dosimeters located at nine points on the site perimeter and at two nearby ranches. The limit of detection for these dosimeters is 20 mR. One dosimeter at a point opposite cobalt–60 irradiation facility recorded 92 mR for the 6-month period. All others were below the limit of sensitivity or less than 0.005 mR/hr.

Domestic water samples were collected monthly from nine nearby sources. The alpha radioactivity concentrations fluctuated from the limit of sensitivity (5.0 pCi/liter) to a high of

**Table 4. Average radioactivity in air particulates around the Livermore site**

| Sampling location | Number of samples | Alpha radioactivity [a] (pCi/m³) | | Beta radioactivity [a] (pCi/m³) | |
|---|---|---|---|---|---|
| | | Average | High | Average | High |
| 1 | 29 | 0.0002±0.0001 | 0.0002±0.0001 | 0.196±0.020 | 3.231±0.32 |
| 2 | 29 | 0.0002±0.0001 | 0.0010±0.0003 | 0.231±0.023 | 4.639±0.46 |
| 3 | 19 | 0.0010±0.0003 | 0.0010±0.0003 | 0.170±0.017 | 2.223±0.22 |
| 4 | 19 | 0.0010±0.0003 | 0.0010±0.0003 | 0.202±0.020 | 2.223±0.22 |
| 5 | 25 | 0.0010±0.0003 | 0.0010±0.0003 | 0.146±0.015 | 2.083±0.21 |
| 6 | 25 | 0.0010±0.0003 | 0.0010±0.0003 | 0.152±0.015 | 2.164±0.22 |
| 7 | 20 | 0.0010±0.0003 | 0.0010±0.0003 | 0.116±0.012 | 1.220±0.12 |
| 8 | 18 | 0.0010±0.0003 | 0.0010±0.0003 | 0.172±0.017 | 1.832±0.18 |
| 9 [b] | 14 | 0.0010±0.0003 | 0.0010±0.0003 | 0.025±0.003 | 0.045±0.005 |
| 10 | 23 | 0.0010±0.0003 | 0.0010±0.0003 | 0.162±0.016 | 2.177±0.22 |
| 11 | 26 | 0.0010±0.0003 | 0.0010±0.0003 | 0.155±0.016 | 2.111±0.21 |
| 12 | 30 | 0.0002±0.0001 | 0.0002±0.0001 | 0.166±0.017 | 2.453±0.25 |
| 13 | 27 | 0.0002±0.0001 | 0.0002±0.0001 | 0.163±0.016 | 2.277±0.23 |
| 14 | 28 | 0.0002±0.0001 | 0.0002±0.0001 | 0.194±0.019 | 3.118±0.31 |
| 15 | 30 | 0.0002±0.0001 | 0.0005±0.0002 | 0.194±0.019 | 3.277±0.33 |
| Overall average | | 0.0010 +0.0003 −0.0007 | | 0.169±0.017 | |

[a] Limits of sensitivity: locations 3–11 0.0010 pCi/m³ (alpha radioactivity), 0.010 pCi/m³ (beta radioactivity)
locations 1–2; 12–15 0.0002 pCi/m³ (alpha radioactivity), 0.0020 pCi/m³ (beta radioactivity)
Variations in limits of sensitivity result from differing sample flow rates.
Applicable standards of comparison stated in AEC Manual Chapter 0524 are 0.040 pCi/m³ for alpha-particle emitters, and 1 pCi/m³ for beta-particle emitters.
[b] Site was not in operation until March 21.

21 pCi/liter. A resample showed the high location to be below the limit of sensitivity. The beta radioactivity fluctuated from the limit of sensitivity (1.8 pCi/liter) to 8 pCi/liter. The average alpha radioactivity concentration was $\leq$6.3 pCi/liter, and the average beta radioactivity concentration was 2.6 pCi/liter. The average alpha and beta radioactivity concentrations were below the respective AEC standards of comparison of 10 and 100 pCi/liter.

The average tritium content was at or below the limit of sensitivity (5,000 pCi/liter), which is well below the standard of comparison of $5 \times 10^6$ pCi/liter.

Samples were collected every Monday, Wednesday, and Friday at the laboratory sewer discharge. On May 25, a 3-day sample was analyzed which contained an alpha radioactivity concentration of 280 pCi/liter. At no time was the concentration guide for uncontrolled drinking water exceeded.

For the 6-month period of January to June 1967, the average alpha radioactivity concentration in laboratory sewage samples was 154 pCi/liter, mostly as a result of the May release, and the average beta radioactivity concentration was 79 pCi/liter. The average tritium concentration was $8.9 \times 10^4$ pCi/liter. Grab samples are collected monthly at the city of Livermore sewage disposal plant to assure that the liquid effluent from the laboratory is not creating abnormal radioactivity concentrations either in the oxidation ponds (which overflow into a natural waterway) or in the dried sludge (which is used as an agricultural soil conditioner).

Samples of top-layer soil are collected quarterly at the 19 sampling stations surrounding the Livermore site. The alpha radioactivity fluctuated from the limit of sensitivity (1.5 pCi/g) to 13 pCi/g. The beta radioactivity fluctuated from the limit of sensitivity (3.5 pCi/g) to a high of 15 pCi/g. The average alpha radioactivity was 2.0 pCi/g and the average beta radioactivity was 8.2 pCi/g. The concentrations detected are within the normal range for soil in the Livermore Valley.

Average radioactivity levels in monthly milk samples amounted to 4 pCi/liter of cesium–137 and $\leq$1 pCi/liter of cesium–141 –144, for the two Livermore dairies. The average tritium concentration in milk was at or below the limit of sensitivity (5,000 pCi/liter). These levels closely correspond to those for a dairy in a neighboring valley about 25 miles from Livermore.

*Site 300*

The high explosive test area at Site 300 (figure 3) covers 10-square miles in the hills in a very sparsely populated ranching area about 15 miles southeast of Livermore and 8 miles southwest of Tracy. The chief area of concern for Site 300 is Tracy. The population there is about 15,000. Air and water samples are taken to determine whether operations at Site 300 are changing the normal radioactivity levels in the vicinity. The eight air samplers at Site 300 are operated at about 50 cfm on a continuous basis with the filter papers being changed on regular schedule. Most of these air samplers are located within the boundaries of the test site due to unavailability of power facilities offsite. Water samples are taken from six onsite wells because they are the only readily accessible sources of underground water. Samples are collected from streams only during the winter months when water flow exists. Soil samples are collected quarterly at nine offsite locations. Only top layer soil is collected to determine fallout concentrations. All air, water, and soil samples are processed at the laboratory in Livermore. The average radioactivity levels in samples collected are summarized in table 4.

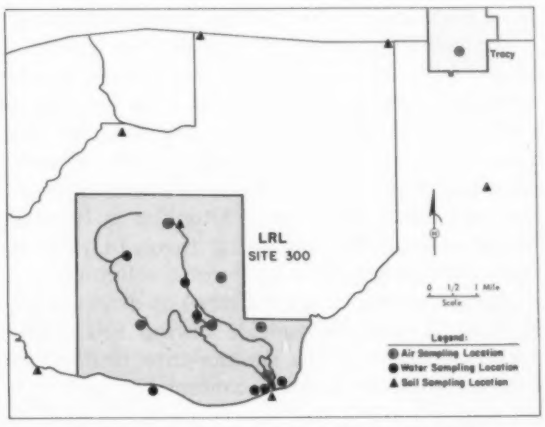


**Figure 3. Sampling locations at Site 300, LRL**

Table 4. Environmental sampling, LRL Site 300 January–June 1967

| Type of sample (concentration units) | Average alpha radioactivity | Average beta radioactivity |
|---|---|---|
| Air (pCi/m³) | 0.0005 | 0.153 |
| Water (pCi/liter) | <5.0 | 4.8 |
| Soil (pCi/g) | 2 | 9 |

Recent coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| January–June 1966 | June 1967 |
| July–December 1966 | November 1967 |

## 2. Mound Laboratory January–June 1967 [2]

*Monsanto Research Corporation*
*Miamisburg, Ohio*

The environmental monitoring program for Mound Laboratory is planned and coordinated with all of the projects conducted at the laboratory. Air and water monitoring in the uncontrolled environs surrounding the laboratory is specific for the radionuclides which could be released to the environment. Only polonium–210, plutonium–238, and hydrogen–3 (tritium) are potential environmental contaminants.

### *Air monitoring*

Mobile air monitoring equipment, mounted on a 1-ton panel truck, for measurement of tritium and collection of particulate alpha-particle emitters was used in the routine monitoring of environmental air in a network of 111 locations within a radius of 20 miles from the laboratory during the collection period. The choice of sites on a given day was dependent upon the wind direction at the time of collection.

Airborne polonium and plutonium particulates are collected with a high volume air sampler. The filter papers are then processed such that counting results are specific for polonium and plutonium. One fourth of each filter paper is processed by spontaneous deposition to isolate polonium. Plutonium is isolated by processing the remaining three fourths of each filter paper through a resin column.

Airborne tritium is monitored by drawing air through a calcium chloride drying tube. The water collected in the sample tube is distilled and analyzed for tritium content.

Beginning January 1, 1967, all particulate air samples collected in the same zone, in the same range, and on the same day are combined before processing and are considered as one sample. This is done to improve the lower detectable limit for plutonium.

The results of the airborne monitoring program are presented in tables 5, 6 and 7. The average concentration of plutonium, polonium, and tritium in the environment are below the AEC radiation protection standards.

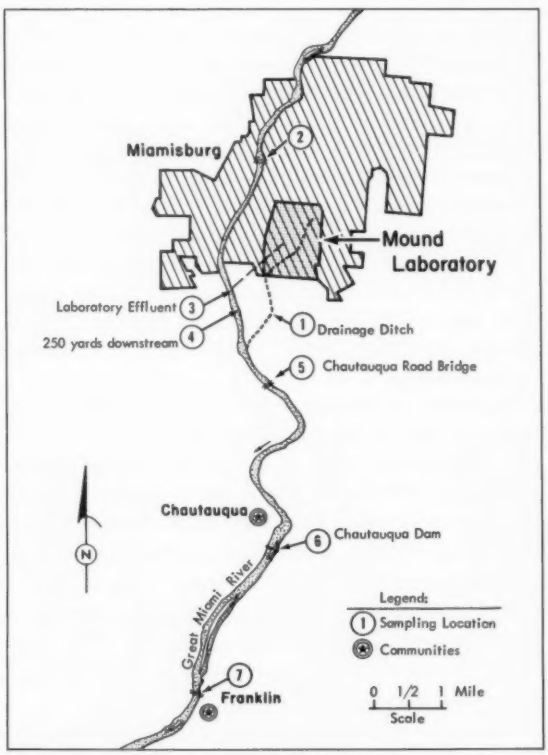


Figure 4. Water sampling locations, Mound Laboratory

[2] Summarized from "Environmental Monitoring Report: January–June 1967" (MLM–1425).

**Table 5. Atmospheric monitoring of polonium-210 Mound Laboratory environs, January–June 1967**

| Range (miles) | Number of samples | Concentration [a] (pCi/m³) | | Average as percent of AEC standards [b] |
|---|---|---|---|---|
| | | Maximum | Average | |
| 0–3 (upwind) | 24 | 0.0466 | 0.0170 | 0.09 |
| 0–3 (downwind) | 23 | .1047 | .0134 | .07 |
| 3–5 (downwind) | 24 | .0533 | .0169 | .08 |
| 5–10 (downwind) | 24 | .0422 | .0147 | .07 |
| 10–15 (downwind) | 24 | .0323 | .0142 | .07 |
| 15–20 (downwind) | 23 | .0265 | .0107 | .05 |

[a] Lowest detectable level (LDL) for polonium-210 in air is 0.0080 pCi/m³ for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 0.0053 pCi/m³ for samples collected 0–3 miles downwind and 15–20 miles downwind. All values which were not detectable were set equal to these values when average values were calculated.

[b] The applicable AEC radiation protection standard for polonium-210 in air is 20 pCi/m³.

**Table 6. Atmospheric monitoring of plutonium-238 Mound Laboratory environs, January–June 1967**

| Range (miles) | Number of samples | Concentration (pCi/m³) [a] | | Average as percent of AEC standards [b] |
|---|---|---|---|---|
| | | Maximum | Average | |
| 0–3 (upwind) | 25 | 0.2822 | 0.0162 | 23.14 |
| 0–3 (downwind) | 25 | .1217 | .0114 | 16.28 |
| 3–5 (downwind) | 25 | .0579 | .0080 | 11.43 |
| 5–10 (downwind) | 24 | .0111 | .0034 | 4.86 |
| 10–15 (downwind) | 25 | .0562 | .0051 | 7.28 |
| 15–20 (downwind) | 25 | .0238 | .0034 | 4.86 |

[a] Lowest detectable limit (LDL) for plutonium-238 in air is 0.0013 pCi/m³ for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind and 10–15 miles downwind. The LDL is 0.0009 pCi/m³ for samples collected 0–3 miles downwind and 15–20 miles downwind. All values which were not detectable were set equal to these values when average values were calculated.

[b] The applicable AEC radiation protection standard for plutonium-238 in air is 0.07 pCi/m³.

**Table 7. Atmospheric monitoring of tritium, Mound Laboratory environs, January–June 1967**

| Range (miles) | Number of samples | Concentration (pCi/m³) [a] | | Average as percent of AEC standards [b] |
|---|---|---|---|---|
| | | Maximum | Average | |
| 0–3 (upwind) | 13 | $8.00 \times 10^{3}$ | $8.00 \times 10^{3}$ | 4.00 |
| 0–3 (downwind) | 13 | $12.79 \times 10^{3}$ | $8.60 \times 10^{3}$ | 4.30 |
| 3–5 (downwind) | 12 | $8.00 \times 10^{3}$ | $8.00 \times 10^{3}$ | 4.00 |
| 5–10 (downwind) | 13 | $8.00 \times 10^{3}$ | $8.00 \times 10^{3}$ | 4.00 |
| 10–15 (downwind) | 12 | $8.00 \times 10^{3}$ | $8.00 \times 10^{3}$ | 4.00 |
| 15–20 (downwind) | 6 | $8.57 \times 10^{3}$ | $8.10 \times 10^{3}$ | 4.05 |

[a] Lowest detectable limit for tritium in air is $8 \times 10^{3}$ pCi/m³. All values which were not detectable were set equal to this value when average values were calculated.

[b] The applicable AEC radiation protection standard for tritium in air is $2 \times 10^{5}$ pCi/m³.

### *Water monitoring*

Liquid radioactive waste materials from polonium and plutonium operations at the laboratory are processed in special waste disposal plants designed to reduce radioactivity to a concentration at which it may be discharged to the Great Miami River.

Helium–3, which is purified at the Mound Laboratory, contains small quantities of hydrogen–3 (tritium). Liquid wastes from this operation are treated separately to assure that the radioactivity level is below the AEC radiation protection standard before discharge to the Great Miami River.

**Table 8. Offsite water monitoring for radioactivity, Mound Laboratory environs January–June 1967**

| Nuclide and sampling location [a] | Number of samples | Concentration (pCi/liter) | |
|---|---|---|---|
| | | Maximum | Average [b] |
| Polonium-210 [c] | | | |
| 2 (Upstream from laboratory) | 26 | 4.50 | 1.97 |
| 3 (Laboratory effluent) | 26 | 900.90 | 71.20 |
| 4 (250-yards downstream) | 26 | 234.23 | 13.20 |
| 5 (Chautauqua Road Bridge) | 26 | 3.60 | 1.87 |
| 6 (Chautauqua Dam) | 26 | 3.60 | 1.91 |
| 7 (Franklin, Ohio) | 25 | 1.80 | 1.80 |
| Hydrogen-3 (tritium) [c] | | | |
| 1 (drainage ditch) | 26 | $0.55 \times 10^{6}$ | $0.09 \times 10^{6}$ |
| 2 (Upstream from laboratory) | 26 | $0.10 \times 10^{6}$ | $0.05 \times 10^{6}$ |
| 3 (Laboratory effluent) | 26 | $0.21 \times 10^{6}$ | $0.11 \times 10^{6}$ |
| 5 (Chautauqua Road Bridge) | 26 | $0.07 \times 10^{6}$ | $0.05 \times 10^{6}$ |
| Plutonium-238 [c] | | | |
| 1 (drainage ditch) | 26 | 945.94 | 73.87 |
| 2 (Upstream from laboratory) | 16 | 22.50 | 6.30 |
| 3 (Laboratory effluent) | 14 | 27.00 | 8.10 |
| 4 (250-yards downstream) | 17 | 9.00 | 4.95 |
| 5 (Chautauqua Road Bridge) | 17 | 22.50 | 6.75 |
| 6 (Chautauqua Dam) | 17 | 9.00 | 4.95 |
| 7 (Franklin, Ohio) | 17 | 54.05 | 7.65 |

[a] See figure 4 for number of sampling locations.

[b] The applicable AEC radiation protection standards for uncontrolled areas are as follows:
Polonium-210 in water: $7 \times 10^{3}$ pCi/liter.
Plutonium-238 in water: $5 \times 10^{3}$ pCi/liter.
Hydrogen-3 in water: $3 \times 10^{6}$ pCi/liter.

[c] Minimum detectable level for polonium-210 in water is 1.80 pCi/liter.
Minimum detectable level for hydrogen-3 in water is $0.05 \times 10^{6}$ pCi/liter.
Minimum detectable level for plutonium-238 in water is 4.50 pCi/liter.
All samples which were not detectable were set equal to their respective minimum detectable level when average values were calculated.

Weekly water samples are collected from a drainage ditch and six locations along the Great Miami River as shown in figure 4. Additional samples are taken quarterly at more distant downstream points. The drainage ditch carries all storm sewer water and treated liquid tritium and plutonium wastes from the plant site. Sampling location number 3 (figure 4) is the point of discharge of the liquid polonium waste to the Great Miami River, and number 7, at Franklin, Ohio, is 5 miles downstream from the effluent outfall.

All of the river samples are analyzed for polonium–210 and plutonium–238 and some of the samples are analyzed for tritium. The drainage ditch samples are analyzed for tritium and plutonium–238. Average concentrations of tritium, polonium–210, and plutonium–238 are given in table 8 for January–June 1967.

Recent coverage in *Radiological Health Data and Reports:*

| Period | Issue |
|---|---|
| January–June 1966 | May 1967 |
| July–December 1966 and 1966 summary | November 1967 |

## Reported Nuclear Detonations, March 1968

The Atomic Energy Commission conducted a low-yield nuclear row-charge experiment, called "Project Buggy," at its Nevada Test Site on March 12, 1968. The experiment consisted of a row of five nuclear explosives of simultaneous detonation, having a yield of about 1 kiloton each (equivalent to 1,000 tons of TNT). The explosives were buried at a depth of 135 feet and spaced 150 feet apart and produced a ditch about 80 feet deep, approximately 300 feet wide, and the length was about 900 feet. This experiment was part of the Commission's Plowshare program to develop peaceful uses of nuclear explosions.

On March 14, 1968, the U.S. Atomic Energy Commission also announced that a nuclear test of low yield (20 kilotons or less TNT equivalent) was conducted underground at its Nevada Test Site.

A nuclear test of low-intermediate yield was conducted underground (equivalent to 20 to 200 kilotons of TNT) on March 22 and a test of low yield was detonated underground March 25, 1968, at the Nevada Test Site.

## French Nuclear Weapons Tests, July–October 1966 and June–July 1967[1]

The first series of five nuclear weapons tests by France were conducted in the islands of Tuamotu Archipelago in the South Pacific Ocean from July to October 1966. Explosion 1, held July 2, 1966, was a plutonium fission device fired over the lagoon at Mururoa Island with an estimated yield of 25 to 30 kilotons TNT equivalent. Explosion 2 on July 19th was a plutonium fission device released from an aircraft and exploded in the lower atmosphere with an estimated yield of 70 to 80 kilotons TNT equivalent. On the 11th of September, the third explosion was of the same type as the first, with a yield of about 120 kilotons TNT equivalent. The two concluding explosions were of higher yields and apparently involved thermonuclear reactions; explosion 4, September 24, was an experimental device utilizing plutonium and thermonuclear materials exploded over the lagoon at Fangataufa Island with an estimated yield of about 150 kilotons TNT equivalent. Explosion 5, held on October 4th was the same as explosion 4; however, it was exploded over the lagoon at Mururoa Island with an estimated yield of 200 to 300 kilotons TNT equivalent. The above information on the tests was drawn largely from the Paris press as no official statement has been made on the actual yields of the explosions (*1*).

The second series of tests at the site were carried out in June and July 1967. The following information on the tests was given in official statements released by the French Government. There were three explosions held; June 5, June 27, and July 2, 1967, respectively. All three explosions were above the lagoon at Mururoa Island, and the weapons, described as experimental devices of low yield, were supported on balloons (*2*). "Low yield" is defined by the U.S. Atomic Energy Commission as being less than 20 kilotons TNT equivalent.

REFERENCES

(*1*) GIBBS, W. J., J. R. MORONEY, D. J. STEVENS, and E. W. TITTERTON. Fallout over Australia from nuclear weapons tested by France in Polynesia from July to October 1966. Australian J Sci 29:407–417 (November 1967).

(*2*) GIBBS, W. J., J. R. MORONEY, D. J. STEVENS, and E. W. TITTERTON. Fallout over Australia from nuclear weapons tested by France in Polynesia during June and July 1967. Australian J Sci 30:217–226 (December 1967).

[1] G.m.t., Greenwich mean time for actual dates listed.



☆U. S. GOVERNMENT PRINTING OFFICE : 1968 302-807/9

## SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

SUMMARY OF IRON–55 CONTAMINATION IN THE ENVIRONMENT AND LEVELS IN HUMANS. *Warren A. Brill, Radiological Health Data and Reports, Vol. 9,* April 1967, pp. 195–201.

Levels of iron–55 in the environment and in food sources have been summarized. The average body burdens and resulting doses to the erythrocytes (red blood cells) of selected Alaskan Eskimos, and residents of the States of Washington, New York, and New Jersey are compared. Considering the erythrocytes as the critical organ, the dose rate from 1 pCi iron–55/mg stable iron is 0.095 mrad/yr. A body burden of 8 nCi, the average for Richland, Wash., residents, yields a yearly dose of 0.19 mrad, while 1,100 nCi, the average body burden for Eskimos on fish diets, yields a yearly dose of 26 mrad.

KEY WORDS: body burdens, blood dose, environment, erythrocytes dose, Eskimos, fallout, food chain, iron–55, marine organisms, U.S. regions.

---

**ORDER BLANK FOR RHD&R**

**To: Superintendent of Documents**
**Government Printing Office**
**Washington, D.C. 20402**

**Please enter my subscription for Radiological Health Data and Reports. I am enclosing Money Order ☐ Check ☐ for this subscription. ($5.00 a year; $1.50 additional for foreign mailing.)**

**Please address RHD&R as follows.**_____

_____

_____

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C., 1968

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Subscription price $5.00 a year, $1.50 additional for foreign mailing.
Price for a single copy of this issue is 50 cents.

April 1968

# GUIDE FOR AUTHORS

**The editorial staff invites reports and technical notes containing information related to radiological health. Proposed reports and notes should contain data and interpretations. All accepted manuscripts are subject to copy editing with approval of the author. The author is responsible for all statements made in his work.**

Manuscripts are received with the understanding that other identical manuscripts are not under simultaneous consideration nor have appeared in any other publication.

The mission of *Radiological Health Data and Reports* is stated on the title page. It is suggested that authors read it for orientation of subject matter.

*Submission of manuscripts*

Send original and one legible copy of the paper, typed double-spaced on 8½ by 11-inch white bond with 1-inch margins.

Submitted manuscripts should be sent to Managing Editor, Radiological Health Data and Reports, National Center for Radiological Health, PHS, Rockville, Md. 20852.

*Preparation of manuscripts*

The Government Printing Office style manual is used as a general guide in the preparation of all copy for *Radiological Health Data and Reports*. In addition, *Radiological Health Data and Reports* has developed a "Guide" regarding manuscript preparation which is available upon request. However, for most instances, past issues of *Radiological Health Data and Reports* would serve as a suitable guide in preparing manuscripts.

Titles, authors: Titles should be concise and informative enough to facilitate indexing. Names of authors should appear on the third line below the manuscript title. Affiliation of each author should be given by a brief footnote including titles, professional connections at the time of writing, present affiliation if different, and present address.

Abstracts: Manuscripts should include a 100- to 150-word abstract which is a factual (not descriptive) summary of the work. It should clearly and concisely state the purpose of the investigation, methods, results, and conclusions. Findings that can be stated clearly and simply should be given rather than to state that results were obtained.

A list of suggested keywords (descriptors) which are appropriate indexing terms should be given following the abstract.

Introductory paragraph: The purpose of the investigation should be stated as early as possible in the introductory paragraph.

Methods: For analytical, statistical, and theoretical methods that have appeared in published literature, a general description with references to sources is sufficient. New methods should be described clearly and concisely with emphasis on new features. Both old and new methods, materials, and equipment, should be described clearly enough so that limitations of measurements and calculations will be clear to the readers. Errors associated with analytical measurements and related calculations should be given either as general estimates in the text or for specific data in appropriate tables or graphs, whenever possible.

Illustrations: Glossy photographic prints or original illustrations suitable for reproduction which help enhance the understanding of the text should be included with the manuscript. Graphic materials should be of sufficient size so that lettering will be legible after reduction to printed page size (8½ by 6½ inches).

All illustrations should be numbered and each legend should be typed double-spaced on a separate sheet of paper. Legends should be brief and understandable without reference to text. The following information should be typed on a gummed label of adhesive strip and affixed to the back of each illustration: figure number, legend, and title of manuscript or name of senior author.

Tables: Tables should be self-explanatory and should supplement, not duplicate, the text. Each table should be typed on a separate sheet, double-spaced. All tables must be numbered consecutively, beginning with 1, and each must have a title.

Equations: All equations must be typewritten, preferably containing symbols which are defined immediately below the equation. The definition of symbols should include the units of each term. Special symbols, such as Greek letters, may be printed carefully in the proper size, and exponents and subscripts should be clearly positioned. Mathematical notations should be simple, avoiding when feasible, such complexities as fractions with fractions, subscripts with subscripts, etc.

Symbols and units: The use of internationally accepted units of measurements are preferred. A brief list of symbols and units commonly used in *Radiological Health Data and Reports* is given on the inside front cover of every issue and examples of most other matters of preferred usage may be found by examining recent issues. Isotope mass numbers are placed at the upper left of elements in long series or formulas, *e.g.*, $^{137}Cs$; however, elements are spelled out in text and tables, with isotopes of the elements having a hyphen between element name and mass number; *e.g.*, strontium-90.

References: References should be typed on a separate sheet of paper.

Personal communications and unpublished data should not be included in the list of references. The following minimum data for each reference should be typed double-spaced: names of all authors in caps, complete title of article cited, name of journal abbreviated according to *Index Medicus*, volume number, first and last page numbers, month or week of issue, and year of publication. They should be arranged according to the order in which they are cited in the text, and not alphabetically. All references must be numbered consecutively.

*Reprints*

Contributors are ordinarily provided with 50 courtesy copies of the articles in the form of reprints. In cases of multiple authorship, additional copies will be provided for coauthors upon request.

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
WASHINGTON D.C. 20201

OFFICIAL BUSINESS

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF H.E.W.

If you do not desire to continue receiving this publication, please CHECK HERE ☐; tear off this label and return it to the above address. Your name will then be promptly removed from the appropriate mailing list.